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Empathic Experience Design For Cognitive Impairment

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EMPATHIC EXPERIENCE DESIGN FOR COGNITIVE IMPAIRMENT

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THESIS

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Abstract

Empathic Experience Design (EED) is a technique that lets product designers empathize with their product users with the use of empathic experiences. These empathic experiences are activities that lets designers become immersed in a simulation of the users' typical environment and conditions and gain powerful insights of the user's product experience. The simulation uses "tools" like earplugs and gloves that can simulate specific conditions such as hearing loss, or lack of sensitivity, for example. Literature shows that this empathic approach enables designers to discover unarticulated customer needs known as user latent needs. Latent needs produce significant benefits in the creation of new design solutions that are most likely to be welcomed by the general market. This study seeks to create a simulation that lets designers use EED to empathize with individuals with cognitive impairments. For this purpose, designers, or individuals without impairment, experience a momentarily cognitive overload created by taxing specific cognitive resources. This effect is achieved using cognitive assessments that are able to impose a controlled cognitive load on the designers. By combining EED with the cognitive impairment simulation, a new design method was created. The resulting method was called Empathic Experience Design for Cognitive Impairment (EED-CI). This method was constructed in two steps. The first step was to determine a specific EED design framework that enables the extraction of latent needs. This EED framework leverages on lead users analysis and empathic design, which are two of the most prominent design methods used in the extraction of user latent needs. The second step is to merge this EED design framework with the cognitive impairment simulation and define the final method. Furthermore, EED-CI was also evaluated with respect to its ability to build empathy with the user, and to facilitate the extraction of user latent needs. The evaluation was performed by asking 29 students from the University of Texas at El Paso to complete an analysis

of user behaviors and needs using three specific cognitive impairments as a reference. The analysis was completed before and after an empathic experience using pre, and post-experience interviews. The participants also reported their perception of their cognitive skills and their overall perception of empathy by answering a survey in between the analyses. The results demonstrate that EED-CI is capable of recreating momentary conditions of cognitive impairment in individuals without impairment, and it is also capable of facilitating the extraction of user latent needs.

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Chapter 1: Introduction

MOTIVATION

The success of a product lies in its ability to satisfy user demands and expectations. In the design realm, these requirements are communicated in the form of user needs that have to be extracted by conducting field research with the users. Typical research methods include focus groups, surveying, interviews, usability tests, among others [1]. The purpose of these methods is to engage with the users and give them an opportunity to provide their testimony of the problem and articulate their needs. Often, users are effective at articulating their immediate desires that improve the usability and functionality of the products they are describing. However, there exists the possibility that, for varied circumstances, the users are not able to articulate their needs. This group of needs sometimes end up being the most beneficial for the product, and therefore, for the user. These unarticulated needs are known as user latent needs and represent the focus of interest of EED-CI [2].

User latent needs have a great significance in commercial applications. Products that provide a bigger benefit for the user prevail as stable sources of revenue for companies. While direct needs like color and shape are easier to identify and address, latent needs are harder to extract since frequently customers are not aware of them [3]. To illustrate this concept, let us briefly examine the story of Uber. In 2008, the founders were stranded in the airport of Paris, and as they were waiting to hail a cab, they realized that mobile technology was not being used to provide on-demand transportation [4]. Their idea was to develop a mobile application with which customers could summon a cab, indicate their precise destination, and pay for the service with a few taps on their phone. By 2015, Uber was booking over 2 million rides a day and had an estimated commission from drivers of around $1.5 billion [5]. Looking at this example in retrospective, the

need for on-demand transportation had been evident to the general public, but people naturally assumed that cabs simply needed to be more effective in their service to the public. The revelation of this latent need came by directly witnessing and experiencing the problem in the very context where it occurred. Also, another factor that contributed to the discovery of the latent need, was that the users were entrepreneurs who are individuals with a primed interest in criticizing conventional wisdom and constantly formulate alternative ideas to improve traditional practices. These two factors are the foundational aspects of empathic design and lead users analysis. For this reason, these two methods were considered to develop EED-CI

Lead users analysis and empathic design are two of the most successful methods at uncovering user latent needs [6]. Lead users analysis is a technique that seeks to discover solutions of users located at the forefront of market trends. These individuals are known as lead users because they "lead" the trend [3]. Lead users are characterized for having a vested interest to anticipate and adopt solutions that will become mainstream practices in the general market. Furthermore, in empathic design, designers observe the users as they interact with products of interest during their everyday activities [1]. The contextual information from the user environment gives designers access to information about underlying needs that the users are not aware of during their interaction.

Moreover, one technique of empathic design that is particularly beneficial when working with lead users analysis is Empathic Experience Design (EED). This technique attempts to elaborate on the process of observing the user interacting with the product by allowing the designer play the role of the user. By doing this, the designer is exposed to an immersive experience in which the condition of the users are also simulated. These immersive empathic experiences are expected to highlight underlying needs that are only visible from the perspective of the users. This

approach facilitates conducting empathic design for lead users, a concept known as Empathic Lead Users (ELU) [6]. The systematic combination of these methods provide a solution to significantly improve the identification of latent needs [6].

The approach of ELU focuses on transforming designers into lead users via extraordinary user experiences [6] [7]. People with disabilities are considered a segment of lead users [7]. The ordinary circumstances experienced by this group in their daily life can be regarded as extreme conditions for typical users. ELU captures solutions developed to work around problems that limit the requirements of lead users. The improvements made for these solutions can be, therefore, hugely beneficial for the average user. So far, ELU research has been largely focused on creating empathic experiences that involve physical and sensory restrictions in the exploration of new latent needs [8] [6] [9]. This project seeks to expand the body of knowledge to include the simulation of cognitive impairments.

THESIS STATEMENT

Before this project, latent needs identification in the area of cognition has not been addressed. This project seeks to develop a method to extract latent needs from cognitively impaired users as a source of latent needs, and corroborate its effectiveness at successfully creating empathic experiences. The method is based on a design framework that incorporates simulated cognitive impairments to create lead users. The resulting method from these two elements is called empathic experience design for cognitive impairment (EED-CI). This method is proposed as a tool to improve the designer's effectiveness at uncovering latent needs.

APPROACH

The approach of EED-CI begins with empathic design, which emphasizes a focus on the discovery of the context of the user through direct observation [1]. This empathic perspective enables designers to examine the circumstances experienced by the user. By directly observing the desires and limitations of the user, designers gain knowledge of needs that users are unable to report.

Additionally, another reason to consider empathic design is that it offers a platform to adapt other techniques. Ultimately, empathic design seeks to build empathy by encouraging a direct exposure to the circumstances of the user [6], which can be attained through many existing techniques. Some of those techniques are empathic probes, scenarios, playacting, and modeling, among others. Empathic modeling was chosen as the base technique to further develop the method. This lack of general structure in the empathic design method provides the flexibility to incorporate empathic modeling, lead users, and the cognitive simulation.

The cognitive simulation creates conditions of cognitive overload. Cognitive overload is an effect that occurs when one or more tasks tax specific cognitive resources of an individual. The condition of cognitive impairment is recreated in the simulation when the cognitive overload is sufficient to hinder the cognitive functions. Thus, the method incorporates a set of techniques that use activities to induce a state of cognitive impairment temporarily.

The design techniques for needs analysis are reviewed in more detail in Chapter 2. The psychology background including the models and specific cognitive impairments are presented in Chapter 3. This same chapter describes the process of combining the two concept.

OBJECTIVES

This study considers the development of the EED-CI method in incremental steps. The first step is to establish a specific method and validate its effectiveness at creating empathic experiences. These results will be used for a future study oriented towards design and needs discovery. Therefore, the goal is to provide evidence that specific cognitive impairments can be simulated to produce an empathic experience. The secondary goal, is to provide early evidence that the design framework is able to work along with the simulation to facilitate the extraction of user latent needs. Considering this rationale, the following objectives have been established for this project:

1. To establish a step by step procedure for the method.
2. To evaluate the effectiveness of the simulation at creating empathy.
3. To provide evidence of the ability of the method in identifying latent needs.

The first objective involves supporting the creating of the method procedure with the EED background. This background justifies the structure in the method and the tasks involved in it. It also defines the input and output information going in and out of the method.

The second objective involves analyzing the output information to evaluate the accuracy of the data generated from the empathic experience. This task seeks to distinguish between the simulated conditions that correspond to the description of the user from the ones that do not. In order for the simulation to be successful, it must be representative of the challenges and behaviors observed in the actual user.

The third objective is complementary to the validation of the method. As the focus of this study is to evaluate the empathic experience, a general evaluation of the method would not be complete without a partial examination of its effectiveness at identifying needs, which is the

ultimate purpose of the method. This objective seeks to provide early evidence to demonstrate that the method has the potential to define latent needs. The preliminary information from this objective will later be used to design a more robust and complete design experiment where this quality of the method will be investigated.

SIGNIFICANCE

EED-CI is a promising technique to go one step further in the process of design to reach cognitive issues faced by different types of users [7]. This includes not only individuals with cognitive impairment but also those that suffer from a situational disability [7]. The benefits brought to these persons may also amplify the cognitive capability of individuals without impairment. For example, a code programmer that has to manage big files of code could implement EED-CI and by extracting latent needs that correspond to individuals with a memory-related impairment, the programmer could acquire a solution that helps her/him become able to manage a larger amounts of information. Similarly, this method could enable the analysis of tasks in certain products that require the cognitive involvement of a user. Cellphones, websites, and cars are a few examples of those products.

These empathic experiences can help designers better understand the cognitive limitations of disabled users. With this knowledge, designers can become more effective at developing assistive technology, for example, to facilitate their social integration. This method may also serve to improve the response and empathy of workers that interact with individuals that are disabled, such as clinicians and nurses.

Ultimately, the knowledge gained after empathizing with the user is expected to provide designers with a much richer understanding of latent needs. As discussed earlier, the ability to identify these needs is highly beneficial for users and designers.

Chapter 2: Techniques for Needs Analysis

This chapter reviews the techniques of latent needs discovery to be incorporated in the Empathic Experience Design for cognitive impairment (EED-CI) method. It begins with a consideration of the concept of lead users which is a group with high expectations for financial benefits. It then continues with a description of empathic design focusing on a subset technique known as empathic modeling. The reviews of these techniques serve to support the basis of the construction of the method.

LEAD USERS

Companies are always struggling to adapt their products to the next trend that will capture the biggest market share. Lead users provide information that creates breakthrough advancements in innovation. This group of individuals prevail in conditions of extreme need, and therefore, develop a vested interest to challenge traditional practices and develop new solutions [3]. What distinguishes these individuals from other innovators is that they are at the forefront of market trends. Observing them provides valuable information about the future needs of the general consumer [3].

In the last chapter the example of Uber was described to observe how lead users end up identifying opportunities for improvement where traditional users may encounter the same problem and not be able to recognize new opportunities. When these unique ideas are in alignment with a general market trend, companies can develop a strong competitive advantage. As an example, 3M implemented the lead user's method to focus their product development resources. The implementation of lead users analysis was directly related to the production of $146 million in sales over a 5-year period.

Lead user analysis is a method developed by Von Hippel to enable designers to obtain a much richer understanding of user needs [3]. Hippel argues that when typical research is conducted to define user needs, traditional methods often deliver small, predictable, or incremental improvements and fail to deliver truly disruptive innovation. This limitation happens because the average user experiences an effect called functional fixedness [10]. When users become familiar with a certain process or product, they become unlikely to adopt a different options even if the new option offers relatively higher benefits [11].

Von Hippel's approach focuses on those users that have found ways to prevail in extreme conditions [12]. For example, consider the users of the early bicycle models that prevailed in countryside communities with unpaved trails of the 19th century. Most users become used to the limitations of bicycles to ride on trails. However, among the community, there were some that enjoyed racing on steep hills that demanded a higher performance from their bicycles [13]. This condition provided the ideal environment to challenge the conventional views of bicycles that resulted in the invention of the mountain bicycle with a better capacity to absorb impacts, a reinforced frame, and ability to ride comfortably on rugged terrain [14]. This conceptual design later became adopted by typical users for the benefit of a comfortable ride, embodied in different varieties of bike designs like cyclocross, and the flat-bar road bicycles [15].

Traditional users become disabled to use objects in a novel way. They are not able to think "out of the box" [16] and fail to report needs that could improve the overall quality and effectiveness of a product. Functional fixedness troubles the communication loops between users and designers. Lead users overcome the challenges of functional fixedness by ignoring the norm given and their exceptional circumstances. They also employ products in ways that the

manufacturers did not intend. Sometimes lead users end up defining the basis for entirely different products. According to Von Hippel, lead users are defined by two characteristics [3]:

1.- Lead users face needs that will be general in a marketplace -but face them months or years before the bulk of that marketplace encounters them.

2.- Lead users are positioned to benefit significantly by obtaining a solution to those needs.

Von Hippel describes four steps to apply the concept of lead users. First, establish the trends using marketing research tools to define the characteristics of lead users. Secondly, identify the lead users following the definition of the trend. Third, reach the lead users to begin the development process. Fourth, test the concept product on the general market [3].

In the market trend scheme, Figure 1, lead users are located before the early adopters [3]. In this scheme, lead users are not considered developers nor experts. In spite of this, they adopt technology earlier than the other groups guided by their practices derived from their desire to overcome immediate limitations. Product modifications made by the user are a useful indicator of lead users, and therefore, latent needs [3] [17] [18]. The products used by lead users are also characterized as being customized or improvised.

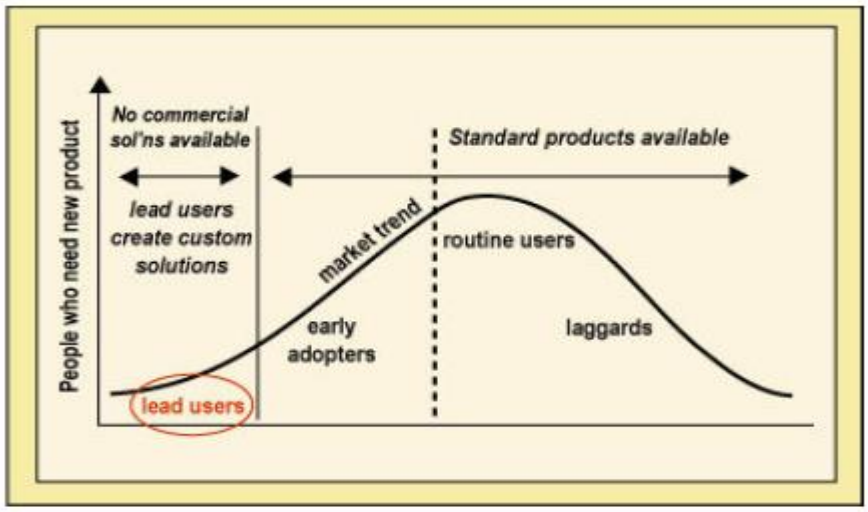

Figure 1. Lead Users in the Scheme of New Market Trends: Lead users are the ones at the forefront of specific trends, and therefore experience needs ahead of the rest [19].

Therefore, lead uses can be easily defined by the attributes in the trend. However, they are often difficult to find, and that is why the lead users analysis thrives on their identification. Many techniques have been adopted to define and find lead users. One of such examples is to learn from people with disabilities. Those users that, due to their condition, employ equipment in non-standard circumstances [20].

In this paper, users with cognitive disabilities are considered the group at the forefront of cognitive limitations. Persons without impairment can also experience "situational disability." Situational disability [7] [21] occurs, for example, when the driver of a moving vehicle is trying to write a text on a phone. Since it is not possible to attend to two different tasks at the same time, there is a temporary attentional impairment. Disabled users and situation disability are two concepts that are explored further in this paper with empathic design.

EMPATHIC DESIGN

Empathic design focuses on everyday life experiences, individual desires, moods, and emotions in human activities as a source inspiration for product development. Different types of

studies have led empathic design advocates to work around four key beliefs. First, people give meanings to things and act on these meanings. Such beliefs evolve as users interact with the product. Second, because design has a significance in real life, design research must be done in real life as well. Third, research methods should be sensory-stimulating, inspiration-enhancing, tested-in-reality, and targeted at the fuzzy front end of the design process. Fourth, design researchers should explore these meanings through design-specific means like rapid prototyping and mock devices [22].

The process of observation is foundational for empathic design [1]. People should be seen and understood from where they stand to contemplate their personal interpretations and feelings, as opposed to be treated as test subjects [23]. User observations and interviews are conducted in the user's environment [24]. Battarbee (2005) points out that, "empathic understanding goes beyond knowledge: when empathizing you do not judge, you 'relate to [the user] and understand the situations and why certain experiences are meaningful to these people'" [25].

By watching consumers use products or services, researchers can gain access to insightful and accurate information that is not accessible through other types of traditional research such as focus groups, ethnographic studies, and usability laboratories, etcetera [26] [1]. With these direct observations in everyday applications and usage contexts, designers may identify "difficulties" that customers may not be able to define or fail to mention in traditional feedback loops [6] [1]. These difficulties are known as latent needs which represent unique possibilities for highly successful products.

Empathic design could be contemplated as a technique that complements the objectives of lead users. Where lead uses define trends to identify users, empathic design observes users define trends. As an example, when an executive from a spray-on cooking oil company found a client

using the product as a lubricant for the blades of his lawn mower, the company was able to address a new market segment [1].

EMPATHIC EXPERIENCE DESIGN FRAMEWORK

In this section, a framework that includes all of the previous techniques is described. This same framework is later used to incorporate the cognitive piece in the following chapter to define the EED-CI method.

This study attempts to expand the body of knowledge in design methodology after empathic experience design (EED). EED, a subset technique of empathic design, is based on enabling the very designers of products to experience the circumstances of their users [26]. EED utilizes empathic experiences, which are simulated activities in which designers plays the role of the actual user. The empathic experience utilizes empathic tools which are certain devices specialized to simulate the conditions of the user [8] [27]. For example, to momentarily limit physical abilities, motion can be restricted through the use of bandages and foam wraps. Also, sensory perception can be limited through the use of gloves, earplugs, and blurry goggles. It is known that this empathic approach has a positive effect on the identification of latent needs [1] [6]. The significant element of our research is to generate the ability to simulate mental conditions as opposed to the conventional EED that so far has been limited to simulate physical or sensory limitations.

This empathic design framework is constructed taking into account three principal methods found in the literature. The first method by Kouprie (2009) presents the process focused on attaining empathy from other individuals. The second method is the very first method in empathic design as defined by Leonard and Rayport (1997) which emphasizes observing product users as the basis for innovation. The third method was developed by Hoss and Roopani (n.d.) which

compiled a general method to use EED. These three techniques result in the standard empathic experience framework, which is used as a platform to include the cognitive piece.

The first method was designed by Kouprie, and it takes into consideration the definitions and process of creating empathy as described in psychology and philosophy. This knowledge is incorporated into a framework oriented towards problem-solving and arbitrary observation. Then, Kouprie presents five steps to first develop empathy, and then use that knowledge to create design solutions as follows [28]:

1. Observation. Definition of who should be observed as well as who should be the observant. This step also defines the element to be observed.
2. Capturing data. Empathy is rather based more on observation than on inquiry. This suggests that questions are relatively discouraged.
3. Reflection and analysis. The team members gather to reflect and review their data. The team needs to take an arbitrary attitude towards the individuals being observed and focus on the data instead.
4. Brainstorming solutions. This activity is carried to transform observations into possible solutions that can be visually represented.
5. Developing prototypes/possible solutions. The final step is to embody the solution with validation purposes.

Kouprie also points out that this process is not bounded by a set of activities, but rather provides a description of the cognitive steps that designers follow to attain empathy. The second method was developed by Dorothy Leonard and Jeffrey R. Rayport. It presents a series of steps to empathize with a customer to generate commercial solutions [1]. This customer orientation is what distinguishes this method from the others. Leonard focuses on five steps:

1. **Observation.** Define who is being observed, who does the observation, and what behaviors should be observed. Observation should occur under normal routines, watching behaviors systematically.
2. **Capturing Data.** Observation is stressed over inquiry. Most of the data is collected from observation and contemplating the situation of the user rather than asking questions. Recording mechanisms can be used, such as video, to facilitate observations.
3. **Reflection and Analysis.** After observing, it follows a stage of reflection upon observations. This is where possible solutions and needs are identified.
4. **Brainstorming for Solutions.** Observations are translated into possible solutions.
5. **Developing prototypes of Possible Solutions**. Prototypes represent communication through a physical representation of a new concept.

The objective of this approach is to encourage innovation that eventually leads to the discovery or development of market-fit products that are uniquely integrated with the experience of the user. The third process considered, is the empathic experience design as presented by Hoss and Roopani in Empathy Tools. Since empathic experience design does not have a specific methodology for implementation, this method compiles different processes and factors described in the literature [8] [9] [29]. This process was also takes into account the process of Lenard and Rayport. The complete method described in this report presents a detailed list of steps to implement EED, as well as different suggestions about how to define and adjust the simulation. The steps are:

1. **Domain.** Understand the specific situation or impairment being simulated.
2. **Materials.** Obtain or invent the tools that will be used to simulate the user situation.

3. **Considerations.** Determine factors such as the level of fidelity expected from the simulation, the process of adaptation to the situation, specific characteristics of the impairment, and the interaction with the product being tested.

4. **Simulation.** Run the simulation.

5. **Record**. Specify what will be the method to document feelings and insights.

6. **Risk and Limitations.** Consider that users with a disability do not get an opportunity to "exit" the impairment, and they actively work to adapt to their situation. There may be risks associated with manipulating devices during the impairment simulation.

With this last process, it is possible to create a unified framework that inherits the ability to create empathy, define unarticulated user needs, and simulate user conditions. Since the simulation is able to incorporate the characteristics of lead users, the framework allows to create lead users out of designers, similar to the ELU approach. The three process of empathy reviewed previously were combined in one single framework by retaining the common steps of each process. The framework is presented in Figure 2 and, from this point, it is referred to as the "design framework" for simplicity.

Figure 2. Empathic Experience Design Framework

The steps in the design framework are defined as follows:

1. **Definition.** Define the problem to be solved. Define whether there is a known aspect of the problem that needs to be observed, or if the purpose is to discover factors. Define the user and whether there is a focus on the typical user or a specific/special user.

2. **Planning.** Specify the desirable level of immersion from the technique and its implications. This includes planning how the simulation is carried out as well as the, domain, materials required, level of fidelity, design tools, and the mechanisms that will be used to record the information.
3. **Immersion.** The designer is tasked to become exposed to the environment of the user and observe. Observation must be done from an arbitrary perspective avoiding generating either inquiries or judgments. The designer should experience empathy with the user by sharing the user's understanding of memories and feelings. Ideas and insights must be documented for the duration of the step.
4. **Analysis.** The designer detaches from the empathic experience. Information that has been recorded is analyzed. Reflections are done to discuss the possible meaning of the information. After gaining knowledge about the user and discussing the meaning of the data, conclusions are drawn in the form of needs. In this step the designer still remains arbitrary.
5. **Solution Generation.** Physical and theoretical solutions are delivered to meet the needs that were identified. Solutions may be presented in prototypes or mockups for rapid verification.

Notice in step two, planning, that the method requires the definition of a domain and parameters. The domain involves the specific details of the lead user. The parameters of the simulation are the details of the simulation such as materials, activities, environment, and duration, among others.

Chapter 3: Development of Method

This chapter presents the background used to develop the empathic experience method. As suggested by empathic modeling, designers must enter into an immersive experience that replicates the conditions experienced by the user. In this study, the target condition is an overall state of cognitive impairment which is recreated using a momentary cognitive overload. The condition is created with a simulation that can also be used as a platform for different impairments and empathic experiences. This flexibility is delivered by the ability to tax the resources of specific cognitive functions as defined by the designer.

Three cognitive disorders are considered to evaluate the effectiveness of the EED-CI method. Summaries of these disorders are presented and described by their behaviors. The cognitive impairments typically seen with these disorders will serve as a guide to construct three different types of empathic experiences in the experiment. The disorders are referred to as "study conditions" in this paper.

Additionally, the psychology models used to complement the empathic experience framework are presented as well. These models include the central bottleneck, dual-task, and the psychological refractory period paradigms. As the resulting framework is the responsible for facilitating the simulation, it was evaluated in a brief preliminary test. This test revealed that the first version of the EED-CI method was not effective at creating empathic experiences. After the test, the framework was modified in order to make the simulation more reliable.

The preliminary method had a configuration that relied on two different activities that, when combined, were expected to produce the cognitive overload. The two activities selected were a cognitive assessment and a performance activity. This method was found to be ineffective because it produced opportunities to defeat the simulation. This problem was resolved by shifting

the configuration of the simulation from dual-tasks to single-tasks. The single-task configuration was similarly tested, and it was found to resolve the issues previously identified.

STUDY CONDITIONS

The first step to construct the simulation, was to find a way in which designers could define the behavior expected from the simulation. One approach was to let them decide which cognitive functions they want to impair depending on the application that they were pursuing. However, a brief search for cognitive functions revealed that, depending on the area of psychology study, there is an intricate network of functions and sub-functions, often times poorly defined or adopted under multiple umbrella terms. For example, attention is a general function that incorporates other definitions like selective attention, vigilance, and task-switching to name a few. Yet, other functions like math and word processing also require the function of attention. Therefore, a model based on specific functions would be unfeasible due to their complex interdependence. Moreover, user experiences involve multiple cognitive functions.

A second approach was to define mental disabilities basing the simulation directly on behaviors. These behaviors are well defined in clinical psychology to conduct rehabilitation. There is a large list of cognitive disorders that could be potentially examined by designers potentially. This study focuses on the top-three most prevalent cognitive disabilities in the US [30]. Those three mental conditions were chosen on their prevalence among the population. Table 1 summarizes the top seven cognitive disorders in the U.S. as classified by the U.S. Census Bureau issued in 2012.

Table 1. Populations of Most Prevalent Cognitive Disabilities in the U.S. (2010)

Cognitive Disability	**Population**
Depression	5,434,000 cases
Trouble coping with stress	4,553,000 cases
Mental/emotional conditions	3,811,000 cases
Attention Deficit and Hyperactivity Disorder (ADHD)	3,583,000 cases
Learning disabilities	2,322,000 cases
Alzheimer's senility	740,000 cases
Intellectual disability	384,000 cases

From this information, the conditions preferred were those that are predominantly cognitive as opposed to emotional. The models presented in this study does not contemplate emotional conditions, and therefore, disorders highly reliant on emotions are discarded. From the list, depression, trouble coping with stress, and mental/emotional conditions were eliminated due to their relation to emotional conditions. From the four remaining disorders, only intellectual disability was discarded due to its similarity to learning disabilities and for its lower population. The selected cognitive disorders were attention deficit and hyperactivity disorder, learning disabilities, and Alzheimer’s dementia.

CHARACTERISTICS OF EACH COGNITIVE DISORDER

In this section, the selected disabilities are described briefly with a summary of their definitions and characteristic behaviors. These descriptions are not meant to be comprehensive since every condition can be elaborated in great detail. Instead, these descriptions provide a basic understanding of the impairments and will be used as a guide in the evaluation of the empathic experience.

ADHD

ADHD is a disorder that hinders individuals' ability to stay focused and control their impulses, or causing them to act without thinking. Individuals with this condition also tend to be constantly active. Individuals must display at least six symptoms of inattention for at least six concurrent months to be diagnosed as ADHD [31] [32]. According to the Center for Disease Control and the American Psychiatric Association, signs of hyperactivity and impulsivity behaviors include:

Impulsivity:

- *Often fails to give close attention to details or makes careless mistakes in schoolwork, at work, or with other activities.*
- *Often has trouble holding attention on tasks or play activities.*
- *Often does not seem to listen when spoken to directly.*
- *Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (e.g., loses focus, side-tracked).*
- *Often has trouble organizing tasks and activities.*
- *Often avoids, dislikes, or is reluctant to do tasks that require mental effort over a long period of time (such as schoolwork or homework).*

- *Often loses things necessary for tasks and activities (e.g. school materials, pencils, books, tools, wallets, keys, paperwork, eyeglasses, mobile telephones).*
- *Is often easily distracted*
- *Is often forgetful in daily activities*

Hyperactivity:

- *Fidgeting and squirming while seated*
- *Getting up and moving around in situations when staying seated is expected, such as in the classroom or in the office*
- *Running or dashing around or climbing in situations where it is inappropriate, or, in teens and adults, often feeling restless*
- *Being unable to play or engage in hobbies quietly*
- *Being constantly in motion or "on the go," or acting as if "driven by a motor"*
- *Talking nonstop*
- *Blurting out an answer before a question has been completed, finishing other people's sentences, or speaking without waiting for a turn in conversation*
- *Having trouble waiting his or her turn*
- *Interrupting or intruding on others, for example in conversations, games, or activities*

Learning Disabilities

Learning disabilities are defined from the definition of disability in order to differentiate individuals that are disabled from those that merely struggling due to circumstantial reasons. The Individuals with Disabilities Education Act (IDEA) defines disabilities [33] as follows:

"*The term 'specific learning disability' means a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations.*

Such a term includes such conditions as perceptual disabilities, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia.

Such a term does not include a learning problem that is primarily the result of visual, hearing, or motor disabilities, of mental retardation, of emotional disturbance, or of environmental, cultural, or economic disadvantage."

There are different types of learning disabilities called specific learning disabilities [34]. The Learning Disabilities Association of America describes the major specific learning disabilities:

Auditory Processing Disorder (ADP): It affects the brain's ability to process or interpret auditory information. Individuals with APD have difficulties recognizing word sounds even when they are loud and clear

Dyscalculia: It affects the ability to comprehend math symbols, counting, and memorizing and organizing numbers.

Dyslexia: Individuals with this disorder develop problems with reading and related language-based skills such as reading fluency, decoding, reading comprehension, recall, writing, spelling, and sometimes speech.

Non-Verbal Learning Disabilities: These individuals show a significant discrepancy between higher verbal skills and weaker motor, visual-spatial and social skills.

Visual Perceptual/Visual Motor Deficit: A disorder that affects the ability to recognize visual information, and performing hand-eye-coordinated activities such as drawing, and copying.

Additionally, the following list summarizes some of the signs related to learning disabilities behaviors.

- *Short attention span*
- *Poor memory*
- *Difficulty following directions*
- *Inability to discriminate between/among letters, numerals, or sounds*
- *Poor reading and/or writing ability*
- *Eye-hand coordination problems; poorly coordinated*
- *Difficulties with sequencing, and/or disorganization and other sensory difficulties*

Other characteristics that may be present:

- *Performs differently from day to day*
- *Responds inappropriately in many instances*
- *Distractible*
- *Restless*
- *Impulsive*
- *Says one thing, means another*
- *Difficult to discipline*
- *Doesn't adjust well to change*
- *Difficulty listening and remembering*
- *Difficulty telling time and knowing right from left*

- *Difficulty sounding out words*
- *Reverses letters*
- *Places letters in incorrect sequence*
- *Difficulty understanding words or concepts, and/or delayed speech development; Immature speech.*

Alzheimer's Dementia

Dementia, on the other hand, is not a specific disease. It is an overall term that describes a wide range of symptoms associated with a decline in memory and other thinking skills. This decline is characterized for its degree of severity that reduces a person's ability to perform everyday activities. Alzheimer's disease accounts for 60 to 80 percent of all cases. Vascular dementia, which occurs after a stroke, is the second most common dementia type. But there are many other conditions that can cause symptoms of dementia, including some that are reversible, such as thyroid problems and vitamin deficiencies [35].

People with dementia may have problems with short-term memory, keeping track of an object they are manipulating like a wallet, making payments, or remembering how to find their way back home. While symptoms of dementia can vary greatly, at least two of the following mental functions must be significantly impaired to be considered dementia:

- *Memory*
- *Communication and language*
- *Ability to focus and pay attention*
- *Reasoning and judgment*
- *Visual perception*

PSYCHOLOGICAL REFRACTORY PERIOD AND CENTRAL BOTTLENECK

The Psychological Refractory Period (PRP) is a phenomenon that occurs when an individual completes a dual-task. It tests whether information processing is serial or parallel with two tasks thought to involve the same process or processing stages. In this paradigm, two speeded tasks or stimuli are presented to the subject in rapid succession [36] [37]. The time in between the presentation of the two stimuli, also known as Stimulus Onset Asynchrony (SOA), is correlated to a lengthening of the subject's reaction time for the second stimulus [38]; namely with less time between the two stimuli, the longer the reaction time to respond to the second task. There are also effects based on instruction for how the two tasks should be prioritized.

In contrast, the first task is typically unaffected. PRP points out that the second stimulus may be delayed because the first stimulus is still being processed and cognitive resources require a short period of time to shift from assignment to assignment [39]. This delay in processing of the second task is thought to reflect a central bottleneck in the availability of similar processing resources.

The existence of a "bottleneck" derives from the observation that cognitive processes need to be worked out in one or a few processors. These processors can accept only one input at a time, and they mostly operate in a serial fashion [40]. Therefore, if two processes require access to the same processor simultaneously, as in the case of a dual-task, only one is granted access while the second one is placed on queue.

The central bottleneck model is, however, still being debated. Evidence disproving the central bottleneck came from a study that achieved "perfect time sharing". Perfect time sharing is observed when the PRP effect is not observed in a dual-task exercise. The study involved a process

of repetitions and learning. This study showed that it is possible to complete a dual-task, and yet, obtain stand-alone reaction times [41].

Similarly, some studies suggest that there is a finite number of shared limited resources. Therefore, it would be possible to achieve dual-tasking with no interference if the two tasks do not involve common cognitive resources [42].

Another instance where the PRP effect does not appear is when the SOA is a long period. For example, when the period is longer than 2 seconds cognitive resources can be reallocated before interference occurs. Reaction times (RT) of the second task tend to converge to stand-alone RTs at longer SOAs [43]. As the SOA period is elongated, the first task processing is completed preventing the interference.

The PRP paradigm and the central bottleneck model provide the basis for the creation of a cognitive impairment simulation. The PRP paradigm suggests the existence of a finite number of shared cognitive resources, or processors, that can attain multitasking when their cognitive processes do not interfere. However, individually, these cognitive resources operate serially and have a limited amount of capacity to process information. When two processes use the same cognitive resource it creates an interference that forces prioritation placing one of the tasks on queue. Similarly, the central bottleneck model predicts that higher cognitive loads will tax the cognitive resources causing a delay in reaction time. Thereby, cognitive overload can be attained by both multi-tasking or simply increasing the cognitive load from a task.

EED-CI METHOD.

The EED-CI method is created by combining the design framework with the cognitive overload simulation. Two configurations were considered to create the cognitive overload after reviewing the PRP paradigm, and the characteristics of the theoretical central bottleneck model.

The two configurations had the objective of overloading single cognitive resources in order to cause delays in reaction time and, thereby, mimic cognitive impairment.

The first configuration used two simultaneous tasks intended to interfere common resources and create the PRP effect. The two tasks were a cognitive assessment as the primary task, and a customized activity intended to represent a typical behavior of the user as the secondary task. In contrast, the second configuration was based on using a single task that featured an adjustable parameter that can increase the level of cognitive requirements of the task.

A set of preliminary tests were conducted with two volunteering students to understand the overarching effect of each of these configurations. In summary, the first configuration caused the participants to show minimal signs of the PRP effect. However, the volunteers reported not experiencing any level of impairment. On the other hand, the second configuration was able to create a sustained state of cognitive overload for the duration of the task, from which the participants reported a sustained perception of cognitive impairment. The second configuration was chosen for its ability to create a more consistent simulation, and therefore, a more reliable empathic experience. The final method is presented in figure 3.

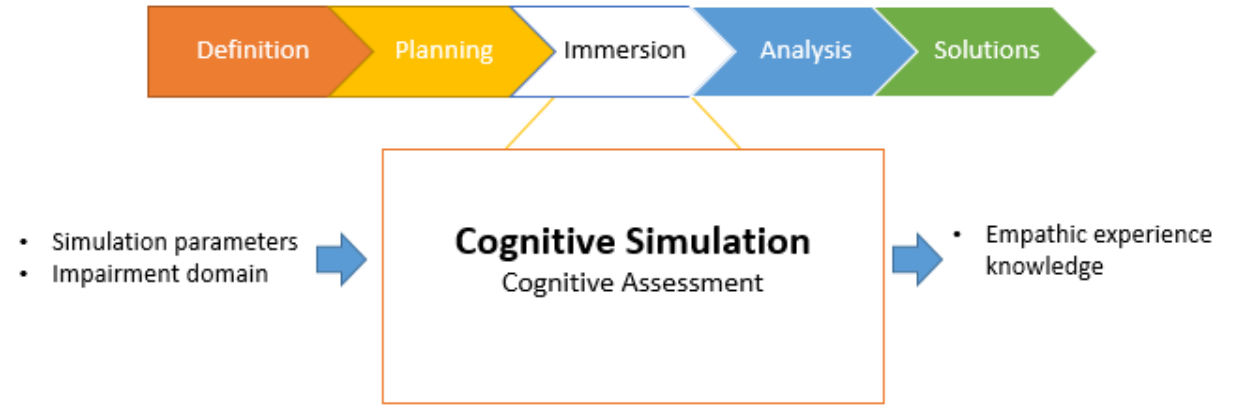

Figure 3. Schematics of EED-CI Method Based on Single-Task Overload.

The design framework is used to incorporate the cognitive overload during the immersion step. The simulation parameters (duration, fidelity, etc.) and the impairment domain (the behaviors and situation associated to the lead user) are introduced to the simulation to create the empathic experience. While for this study, the simulation is based exclusively on cognitive assessments, other activities and product interactions can be used instead, as long as the required level of cognitive overload is met. The knowledge gathered from the experience must be documented to complete the following steps of analysis and generation of solutions.

Cognitive assessments were considered to create the cognitive overload simulation due to their ability to cause a consistent and predictable cognitive load, and for their ability to generate a continues log of performance data. Some cognitive assessments also have the characteristics of presenting increasingly difficult tasks, which a desirable attribute to observe for the analysis of the experiment. For example, a cognitive assessment can require to memorize four items and then recall them. The same task can then increase the number of items to seven, and then twelve. At some point, the amount of information overcomes the subject's ability to process it and creates the overload. The following chapter describes the selection of the cognitive assessments.

The final specification of the EED-CI method completes the first objective of this project. However, the following two objectives represent the greater contribution. Evaluating the creation of the empathic experience and evidence of its ability to generate latent needs are the topic of the study experiment.

Chapter 4: Methods

Experiment Objectives and Hypotheses

An experiment was developed to evaluate the effectiveness of the Empathic Experience Design for Cognitive impairment (EED-CI) method at generating empathic experiences. The objectives of the experiments are the following:

1. To evaluate the effectiveness of EED-CI in recreating the behaviors observed in individuals with impairment.
2. To evaluate the effectiveness of EED-CI in enabling designers to identify user latent needs.

This experiment considered two main hypotheses. First, that adding the ability to simulate cognitive conditions to empathic modeling, will facilitate designers an understanding of the immediate conditions faced by the user. This knowledge gained from the empathic experience is expected to enhance designers' ability to identify implicit needs. However, this hypothesis assumes that cognitive overload can be effectively simulated in the first place. The creation of a cognitive overload from the simulation is, therefore, the primary hypothesis.

The first hypothesis indicates that an empathic experience can be created by simulating a cognitive overload similar to that experienced by an individual with a cognitive impairment. This hypothesis is challenging due to current inability to clearly examine the insides of any individual's mind. For this reason, the empathic experience is analyzed from a "black box" perspective [44]. In a black box, the internal structure of a system cannot be observed. By comparing the behaviors that are simulated with the behaviors that are actually created, it is possible to evaluate the empathic experience.

The second hypothesis examines an anticipated increment in the number of latent needs. Latent needs are a useful indicator of the empathic experience effectiveness. Lin as the author of

ELU, defines latent needs as those needs that represent a significant change from the initial design and that did not fit the category of a direct need [6]. Lin also includes in this definition those needs that "represent an innovative insight into the product and/or product usage conditions." A needs analysis is used to extract user latent needs by identifying the new needs generated after the empathic experience. This analysis is expected to reveal specific needs that are only accessible from the experience.

EXPERIMENTAL PROTOCOL

Provided these hypotheses, the experiment design is constructed by conducting a pre, and post-evaluation before and after the experience. Figure 4 shows the schematics of the design of the experiment. The experiment involved recruiting a target population of 30 participants that to be complete the three modules of the protocol.

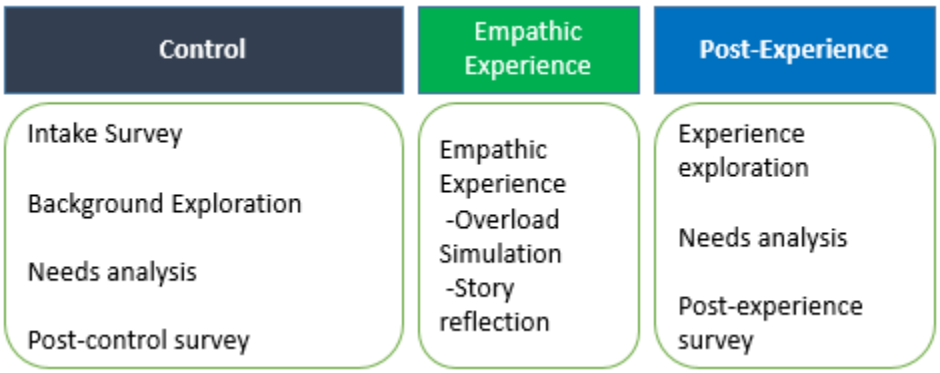

Figure 4. Schematics of the Experimental Design.

The evaluations consist of a combination of interviews and surveys that explore the participants' perception of the impairment before and after the experience. The evaluation also includes a needs analysis of products that were selected for each impairment. The sections below describe each module in detail. The participants complete the entire protocol including control and

experience portions. The interventions between the stages serve as checkpoints to collect the insights of the participants

Recruitment

The criteria used to recruit participants includes individuals that are UTEP students, do not present cognitive impairments, are fluent in English, and are at least 18 years old. Aspects like background and classification level are not defined since the empathic experience is expected to produce the same benefits across these groups. Other aspects such as gender, and ethnicity are not regarded as important aspects.

There is an anticipated number of 30 participants completing a single trial each. Every trial evaluates one of the selected disabilities or study conditions. The disabilities are related to one cognitive test and one device for needs analysis. Participants' names, emails, and participation consent were collected. They were given a participant ID and assigned a study condition.

The answers of the participants were audio recorded. The experiment took place in a quiet room where the surveys and interviews are completed orally. A desktop computer was used to run the cognitive assessments. Once the information and consent of the participants was obtained the protocol began.

Control Module

Step 1 - Recruitment and Intake Survey The purpose of the control module is to obtain a reference baseline of behaviors and needs. It begins with the intake survey shown in Figure 5. The surveys seek to monitor the cognitive skills of the participants and are administered before and after each of the two modules. There are up four questions in every survey and they take less than a minute to complete each. These surveys evaluate the participants' general perception of

their own cognitive skills. Questions were structured so that responses could be recorded using a Likert scale. Response options ranged from 0 to 10, with 0 being very impaired, and 10 being very enhanced.

Questions 1 aims to obtain an average perception of their cognitive skills. This average works as a baseline to evaluate their perception before and after every module. In question 2 participants rate their immediate cognitive skills. Questions 3 and 4 try to explore whether the participants were exposed to any event that should be taken into consideration for their current cognitive state.

1. On a **typical day (average)**, how would you rate your general cognitive skills (e.g. the clarity of your thoughts) on the following scale:

0 1 2 3 4 5 6 7 8 9 10

Very impaired Neutral Very enhanced

2. How would you rate your **current (immediate)** cognitive skills on the following scale:

0 1 2 3 4 5 6 7 8 9 10

Very impaired Neutral Very enhanced

3. Do you sense that your cognitive skills have improved or worsened due to any circumstance or event during the past 24 hours?

0 1 2 3 4 5 6 7 8 9 10

Neutral Somewhat affected Very affected

4. If any, what would that event be?

Figure 5. Intake Survey

Step 2 - Initial Needs Analysis: Background Exploration The intervention continues with an interview about the participant's background. Figure 6. In the background exploration, participants are interviewed about their current understanding of their assigned study condition. The participants are asked to define what problems and challenges individuals would face on a regular basis. Participants are expected to reveal their personal experience with and knowledge of the assigned condition. This is used to encourage the participant to generate an unbiased empathic

understanding through, in this part of the experiment, rationalizing and extrapolating from their current understanding.

The questions guide the interview to first establish the experience and familiarity of the participant with the disability. The interview encourages the participant to define limitations they have observed directly. Questions 6, 7, and 8 seek to review the challenges and difficulties experienced by those individuals. In those questions, participants are expected to create empathy using logic. This interview can last for a maximum of 10 minutes.

Background Exploration

1. Are you familiar with the characteristics of [insert condition]?
2. To your understanding, what are the symptoms and behaviors experienced by people with [insert condition]?
3. Are you aware of any particular decline that emerges overtime?
4. Do you know anyone personally, such as an immediate family member, friend, or classmate that suffers from [insert condition]? What has your experience with that person been like? What behaviors have you observed that are particular from this person?
5. Given your current knowledge of this condition, what are the challenges that these individuals experience?
6. What kind of tasks are difficult for them to complete?
7. What causes those difficulties?
8. Discover troubles and challenges in the following categories:
    i. Social interactions
    ii. To live an autonomous/self-sufficient life
    iii. Work life
    iv. Life at home

Product Analysis

1. How can assistive technology be used to help these individuals?
    a. What would you say are the most important factors when designing this device?
    b. How can this device address the challenges that you mentioned? What functions should it perform (i.e. what should it be able to do)?
    c. What additional features should it include?

Figure 6. Initial Needs Analysis Interview

Step 3 - Initial Needs Analysis: Product Analysis This step focuses on extracting needs for the devices that were selected for the impairments. The participants do not interact with the devices. The objective is to create ideas for the devices and create new designs. The resulting

designs needs to reflect the effects of the control and experimental methods. To that purpose, assistive devices, also known as Assistive Technology, were considered since they are regularly used to meet the needs of users with disabilities [33]. The devices presented in Table 2 had been determined via an internet search for assistive technology.

20 different types of assistive devices were found with general and specific assistive purposes. Assistive devices were selected based on the criteria of availability, originality, and applicability. This criterion was defined to reflect the purposes of lead users and empathic design. A device is considered readily available if it is widely distributed to and implemented by users reflecting the market trend. For example, users would be likely to adopt a re-designed wheelchair since it is a readily available product.

Also, they must be original, so as to not bias the participants to come up with trivial designs. A calculator would be an example of a trivial design because there are only a few circumstances where to use it. And it must also be a device that can be generally applied to a certain group of users because such an application should theoretically respond to unmet needs of that group. For example, a technology to assist ADHD should mostly apply to individuals with ADHD. Otherwise, it may be incorporating features meant for the needs of other groups that would be incompatible with the empathic experience. The following table summarizes the technology selected and a brief justification.

Table 2. Selection Criteria for Experiment Devices

Disabilities	Apparatus	Availability	Originality	Applicability
Trouble concentrating or ADHD	Computer-based pen	Different varieties are available for impaired and non-impaired users.	These pens can be applied in multiple circumstances like educational, work, leisure settings, etc. A chip enables incorporating supplemental hardware	It is used in tasks that require sustained attention.
Learning disabilities	Mobile-based learning application	Transferrable via internet, and compatible with current mobile infrastructure	It can be adapted to different learning styles, topics, techniques, trainings, etc. Incorporates auditory, touch, and graphical interfaces and feedback.	The application specifically addresses learning skills
Alzheimer's Dementia	GPS tracker watch	Smart watches are already deployed in the market with different capabilities	Watches are worn throughout the day of their users. A chip enables incorporating supplemental hardware.	Using watches and GPS requires time and locational awareness.

In order to evaluate the effectiveness of the empathic experience at uncovering latent needs, a technique known as priming was used in the needs analysis. Primes are a psychology technique that was introduced into the design space by She [45] [46] [47]. This author defines primes as "an artifact, exposure, or experience that stimulates increased cognitive accessibility of mental content" [48]. Priming designers is primarily a method that encourages designers to generate more varied and original designs.

Priming is an effective technique to increase the amount of features associated with a particular topic. It is derived from a psychological technique used to influence the process of association of ideas. However, while in psychology primes are implicit to generate an unconscious bias, She incorporated primes explicitly by exposing participants to the stimuli directly [49] [50]. Stimuli includes material related to the idea being primed such as images, video, and physical

objects or products [51]. The priming exercises are used to influence the ability of participants to come up with product needs and does not necessarily require the involvement of products.

In the needs analysis interview, the participants are asked to brainstorm ideas to improve these products to assist the target user. Figure 8 shows the three questions that are asked to the participants to complete the needs analysis. The first question asks seeks to describe the ideas that they identify as the most outstanding to the success of the device. This question is further elaborated by asking them to describe the functionality, and physical features to embody those ideas. The investigator encourages participants to describe their ideas with the most detail possible. This portion of the interview lasts for five minutes.

Step 4 - Post-Control Survey The Initial Needs Analysis module is finalized with the post-control survey as seen in Figure 7. This survey is a modified version of the Intake survey that checks if participants were affected by the prior interview. It also asks them if they perceived any change from their perspective.

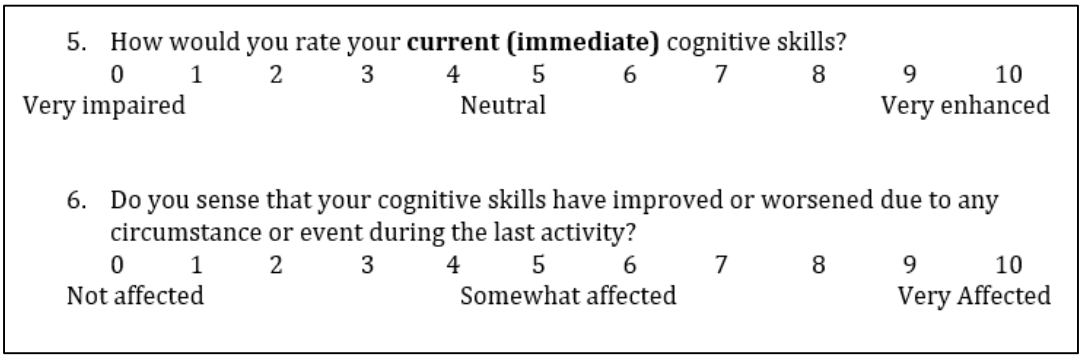

Figure 7. Post-Control Survey

Experimental Module

Step 1 - Empathic Experience In the experimental module the participants go through an empathic experience using the cognitive assessments. In order to increase the ability of the participants to understand the context of the impairment, once they complete the simulation,

they are asked to tell a story of a previous event in their life. This module also includes an interview to explore the experience of the participants during the simulation.

The cognitive assessments correspond to their assigned study condition as shown in Table 4. Cognitive assessments are well known cognitive paradigms and are considered due to their ability to both simultaneously measure performance, and through the assessment, create a cognitive load [52]. These assessments can be found in PEBL2. As an open-source software, PEBL2 (http://pebl.sourceforge.net/#about) lets psychologists customize their own tests. It has been created as a practical way for administering cognitive assessments for clinical research. PEBL2 incorporates a battery (a set) of specific tests that can be acquired at no cost. Each test is associated with specific cognitive domains, e.g. attention, long-term memory, reaction time, inhibition, etc. There are nearly 70 assessments available in PEBL2. The following criteria was defined from the requirements of this experiment.

- The test must have a duration ranging from 5-10 minutes.
- The test must include at least 10 trials (each with at least 1 data point) and generate a log of reaction metric measurements.
- The test must be able to reflect changes in the performance of the subject through the metrics found in every trial.
- The test must fall within the most predominant cognitive domain in every disability as categorized by the assessments in PEBL2.
- The test must incorporate a parameter that can control the level of cognitive load in every test.

Using this criteria, 28 cognitive tests were identified that meet the criteria. The selected tests can be found in Table 3, and the full list of assessments that meet the criteria can be found in the Appendix A.

Table 3. Selected Cognitive Assessments

Disabilities	**Cognitive assessment**	**Cognitive load parameter**
Alzheimer's senility	Operations Span Task	Amount of letters to remember
Trouble concentrating or ADHD	Stroop task-color stroop	Exposure to stimuli
Learning disabilities	Reading Task	Amount of words embedded in reading

Two cognitive assessments were selected from the list of assessments to evaluate the single-task. The third task was a typical assessment used in learning disabilities, but is not included in PEBL2. The operations span task presents a series of letters, one at a time, for a brief period, that participants need to remember. It then presents a few arithmetic operations that the participant needs to solve. The cognitive load occurs when the two tasks are combined and one arithmetic problem is presented after each letter. The operation can require the participant to remember up to seven letters while simultaneously solving operations. The higher the number of letters, the more likely they will be unable to either remember the letters in the correct order or solve the math problem correctly.

The color stroop task presents the participant with a series of words with a colored font. The words are presented one at a time for a short period of time. The participant is instructed that there are four colors corresponding to the keys one through four. The participant has to identify the color of the font using the keys. When the name of the word corresponds to the color, it is known as a congruent trial. When the word and the color are different, are called incongruent trials.

The participant needs to inhibit the name of the color and identify the font color. The load is placed by presenting congruent and incongruent trials.

In the reading task, participants have to complete a reading on a generic topic. The reading has words embedded in quotation marks that the participants need to ignore. When participants finish the reading, they are given a quiz on the reading that includes mentioning the words they were instructed to inhibit. As more words in quotation marks appear, participant tend to forget the content of the reading. This task was customized assuming that participants are proficient at reading considering that they are university students.

Participants complete the corresponding cognitive assessment from PEBL2. The complete cognitive assessment is loaded on a desktop computer and the investigator provides instructions to complete it. The participants can also read the instructions directly from PEBL2 and they are given an opportunity to get mentally prepared before starting the assessment. The participants solve the assessment in a quiet room to avoid distractions. They are given a maximum of ten minutes to complete the assignment.

Step 2 - Story Reflection In addition, another step was taken to address the issue of the duration of the experience. In order to improve the ability of participants to establish a context, a complementary story exploration was added to the protocol. This addition tries to leverage that knowledge by asking the participant to recall a situation of a previous experience where they encountered a similar feeling. Such situation is expected to include events similar to the factors that led to the cognitive overload. The participant can then describe what was the impact of the cognitive impairment and what mechanisms were used to solve it.

Post-Experience

Step 1 - Final Needs Analysis: Empathic Experience Exploration This activity is followed by an interview to analyze the sensations and insights experienced by the participant. This is completed using the script in Figure 8 that explores their general experience, and then, more specifically the cognitive overload. Question one lets the participants express their overall impression. From this general explanation, question 2 seeks to understand whether there was a situation of cognitive overload. The participants may refer to their cognitive overload as those moments when they were overwhelmed by, or unable to complete the tasks. Question 3 explores further how the impairment happened and whether they were successful at implementing strategies to deal with the challenge.

Experience Exploration

1. Can you tell me about your experience? How did it make you feel?
2. Regarding the tasks that were the most difficult from the test,
    a. How did the difficult tasks hinder your ability to solve them?
    b. How did you approach that challenge? Did you used any particular strategy?
    c. How would you describe the sensations that you experienced when you were completing these tasks? Be as specific as possible.
3. I want you to concentrate on the moment when you became cognitively overloaded (i.e. when the tasks became overwhelming).
    a. What were you thinking?
    b. What other life experiences have occurred to you where you experienced the same feeling? Touch upon the following points
        i. Circumstance
        ii. What caused the discrepancy?
        iii. Events led to that moment
        iv. What did you do to solve the situation?
        v. How could you have prevented the cognitive overload from happening in the first place?

Figure 8. Experience Exploration Questions.

All questions from interviews throughout the study are open ended to encourage free conversation. The participants are allowed to go off-script if their answers are considered relevant

or if they touch multiple questions at once. Participants answers are also encouraged to last as much as possible but there is a time cap to keep the protocol within a maximum of 60 minutes.

Similar to Step 2, after participants reviewed their experience, their empathic ability is examined again. To ensure that participants are actually using the knowledge gained from the experience, they are asked to think empathically of a hypothetical individual that undergoes a similar cognitive overload on a regular basis as seen in Figure 9. Following this indication, there is a set of questions that seek to describe the challenges and difficulties faced by these users. These two interviews last for a maximum of 15 minutes.

Story exploration

I am going to ask you to imagine a hypothetical situation for a person that experiences the same cognitive overload all the time. Imagine the same feeling that you had in the situation that you described. Suppose that this person faces this same challenge all day every day. Let us utilize this situation to answer the following questions:

1. Considering the experience you've just had, what challenges do you think individuals who have this condition might experience?
    a. What tasks are difficult for this person to complete?
    b. What causes those difficulties?
    c. How does this condition affect their social interactions?
    d. Does this condition create a risk for them to live an autonomous/self-sufficient life?
    e. How would this condition impact their work life?
    f. How would this condition impact their life at home?
    g. How would this condition impact a person's ability to navigate their environment?

Figure 9. Story Exploration Script

Step 3 - Final Needs Analysis: Product Analysis Similar to the Control Module, the Experimental Module concludes with a second product analysis interview identical to the first which is presented in Figure 6. This second interview leverages the participant's insights gained from the experience.

Step 4 - Post-Experience Survey The first question rates their perception of the empathy they gained after the experience. This rating is useful to compare it with the overall empathy that they demonstrated during the interview. The following question rates their cognitive abilities as in the previous surveys Figure 10.

7. To what extent did these activities enhance your empathy with individuals with disabilities?

0 1 2 3 4 5 6 7 8 9 10

Not enhanced Somewhat enhanced Very enhanced

8. To what extent did the empathic experience impact your **current (immediate)** cognitive abilities?

0 1 2 3 4 5 6 7 8 9 10

Not enhanced Somewhat enhanced Very enhanced

Figure 10. Post-Experiment Survey

DATA ANALYSIS

The data gathered from the two evaluation modules are analyzed using qualitative, and statistical analysis. This section describes the steps followed to select and classify the experimental data. Appendix B shows an example of the process of selection and classification of topics.

Step 1. Transcription. The interviews and questionnaires are recorded in audio during the experiment session. The audio is transcribed into text word by word. Sometimes, participants hesitate and mumble before expressing their full comments. These vocal expressions and incomplete ideas are excluded to reduce the time of transcription.

Step 2. Themes Identification and Labeling. The transcriptions from the audio are coded using Nvivo Pro 11 manufactured by QSR (http://www.qsrinternational.com/nvivo-product/nvivo11-for-windows). The method used to identify the themes consists of capturing statements, or comments, that allude to repetitive topics, as well as those statements that contradict such topics [53]. Special emphasis is made to comments where participants show a particular concern. For example, when a participant begins with a comment such as “it is very important that…” or “I think the biggest thing is…”.

When a potential topic is discovered, it has to be labeled to form a theme. The labeling process seeks to maintain a balance between conveying the specific idea from the comments, as well as staying at a general level to capture as many comments as possible under the same theme. For example, participants made several comments about the tendency of individuals with Alzheimer to forget their memories. The theme chosen for these comments is "loss of memory." Some comments focused on the users' behaviors of forgetting things, being unable to remember names of people, forgetting places or difficulty remembering specific tasks. All of those comments describe the loss of memory. In comparison, a comment like, "they don't know where they are sometimes" is different because the focus of the comment is on their awareness as opposed to their memory. This last comment is coded as "confusion." Other labels could be used for this comment, however, this one allows to include other comments like, "they lose track of things they are doing," and "I think they experience confusion on a regular basis." Words that were used by the participants may be used as theme labels whenever possible.

Step 3. Themes Breakdown. Themes correspond to the protocol step from which they are coded (e.g. behavior themes are extracted during the behavior analysis steps). Figure 11 shows the sources of data for the themes of behaviors and needs.

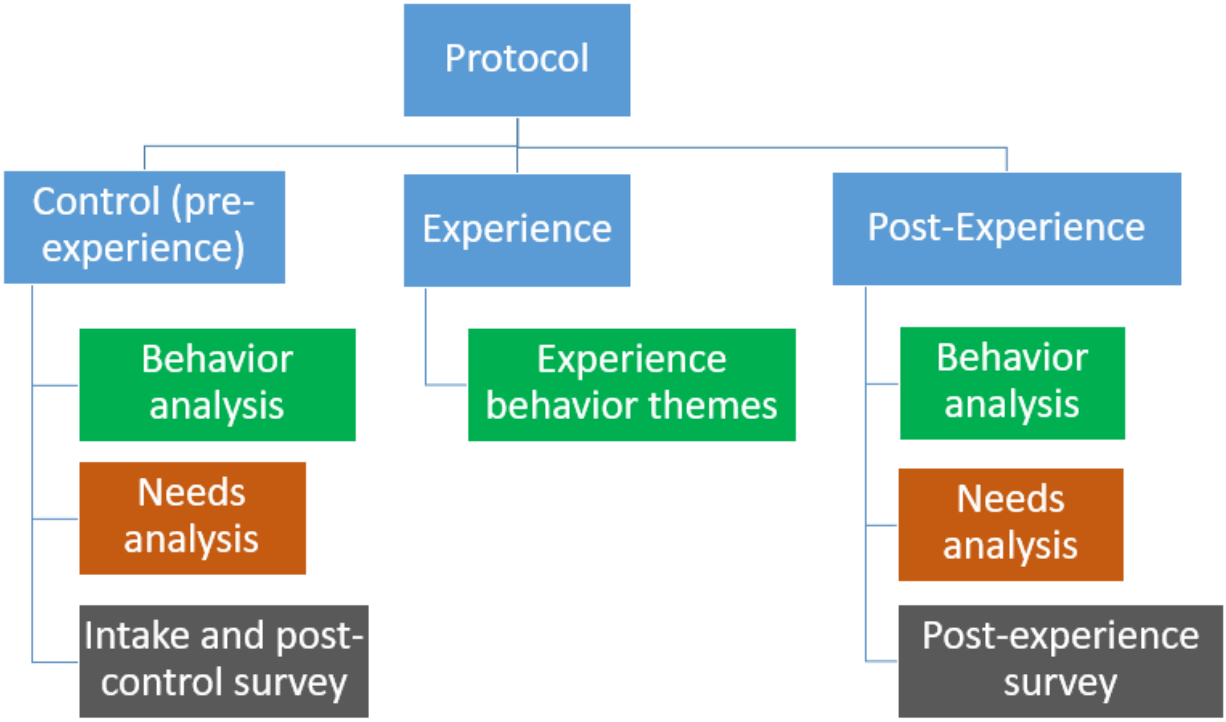

Figure 11. Data Sources in Protocol.

Behaviors themes are found across the three modules. However, behavior themes from the pre, and post-experience modules focus on the user. In contrast, behaviors from the experience focus on the participants. For example, in the pre, and post-experience behavior themes, participants may talk about the user's behaviors of "repeating instructions" and "being hyperactive." On the other hand, behavior themes from the experience module describe the behaviors of the participants from the simulation. For example, participants may relate their experience with comments like "I kept forgetting the words of the task" and "I was unable to complete the task." In this last example, the themes are "loss of memory" and "inability to complete tasks" in reference to the participants. Similarly, needs themes are extracted from the pre, and post product needs analysis and are centered on the user. After themes are obtained from the different steps of the protocol, they are classified to further analyze them. Figure 12 shows the theme classification fields by type.

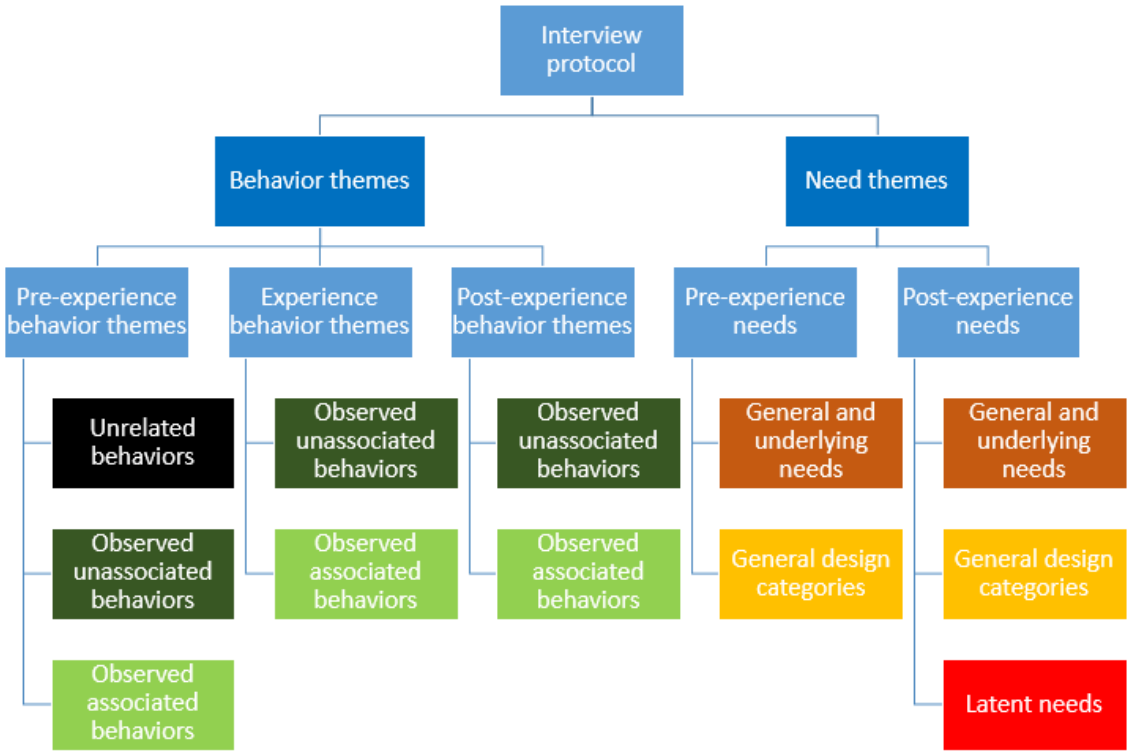

Figure 12. Themes Classification

Step 4. Behavior Themes Classification. Behavior themes are used to determine whether the simulation successfully replicates the impairment. The control module begins with defining and discriminating a group of behavior themes called unrelated behaviors. This classification is derived from the notion that participants describe behaviors from their previous interactions or life experiences with individuals with impairments. These interactions may happen directly in person, or they may come from observing a classmate, or a movie character that has the impairment in question. Unrelated behaviors come from participants that did not have any interaction with individuals with impairment. Therefore, these unobserved behaviors are filtered out because they are likely to be assumptions made by the participants that become visible when comparing the behaviors with the general definition of the impairments. For example, if a participant has never seen an individual with Alzheimer they are likely to report a behavior like

epileptic attacks which, considering the summary description of Alzheimer's in Chapter 3, is not a consistent behavior. This classification is exclusive of the control module because during the experience and post-experience modules participants make their comments with respect to the empathic experience.

Observed behavior themes are further classified as associated and unassociated behaviors. The distinction is that observed associated behaviors are representative of the impairment. For instance, the behavior of "hyperactivity" implies the impairment of ADHD. In contrast, another behavior like "stressful" may have been observed in individuals with ADHD, but it does not imply the impairment, (e.g. a person that experiences stress does not necessarily have ADHD). Observed associated behaviors are selected across the behaviors from the three modules by filtering observed associated behaviors.

Step 5. Needs Classification Likewise, needs are extracted from the product needs analysis portion of the pre, and post-experience modules. The themes obtained from the analysis of the transcripts may include both needs and solutions. Solutions are defined as those themes that involve a specific piece of hardware or functions that do not provide the basis for further solutions. For example, for the electronic pen, a complementary tip that makes the pen work as a stylus is considered a solution because it involves a defined piece of hardware. Also, the theme suggests a stylus as the end solution and prohibits further ideas from being considered. Solution themes imply underlying needs. It is the underlying need what is being considered to classify solutions.

After all themes were converted into needs, they are categorized into broader need concepts. This approach is similar to the one used by Lin, in which direct needs are described in general design categories. These categories describe the overarching aspect of the needs. Category labels must describe general design parameters (e.g. geometry, size, cost), design qualities (e.g.

reliability, aesthetics), or general functions (e.g. connectivity with digital devices, visual interface). These general characteristics seek to distinguish the overarching focus of the needs. For this reason, when subcategories may exist (e.g. visual and auditory interfaces), priority is given to the highest order category (interface). This higher level classification is useful to group needs that focus on the same concept and distinguish them between the ones that are significantly different. These categories are, therefore, considered the overarching needs that are used to identify latent needs.

Step 6. Latent Needs Identification There is one additional criterion to define potential latent needs. If the majority of participants were able to identify the same distinctive need category, it may suggest that the need category is a direct need. Therefore, those distinctive need categories that were identified by three or more participants are also considered direct need categories. Those need categories that are new, well-differentiated from the control and are unique and had been mentioned by a few participants are considered potential latent needs.

Surveys

Similarly, surveys are implemented at the beginning and end of each module, for a total of three. These surveys include a Likert scale which serves to observe changes in the participant's cognitive state due to the empathic element. The Likert scale has 11 options ranging from not enhanced to very enhanced. These surveys seek to observe changes of the participant's perception of their cognitive skills. Participants are asked to rate their cognitive abilities in every survey. Those ratings are compared using a t-test.

This study has received IRB approval that permits the execution of the preliminary study as well as recording participants in video and audio, and making them eligible to earn a $10 gift certificate from the UTEP bookstore. The information of the students remains confidential.

The data was collected in the form of audio recorded interviews that lasted less than 60 minutes in duration. The experiment was conducted with 29 university students as participants (mean age = 23.31 ± 3.59 SD, 8 female). Ten data points were collected for the study conditions of Alzheimer and ADHD, while there were 9 data points for learning disabilities. The last student missed the appointment due to repeated time conflicts. Also, two students were interviewed in Spanish, and their interviews were translated to English by a bilingual speaker. However, the information reported in the results section corresponds to 15 participants, five for each impairment. This portion of the data was utilized due to the outstanding amount of processing required to complete the transcription of the recordings. The remaining data points will be included in the final report of the study. The population from the study includes mostly graduated engineering male students. Most of which were in their early twenties. The population was also predominantly Hispanic, and graduate students.

Chapter 5: Results

After completing the experiment, three main sets of data were extracted: the qualitative from the interviews that includes behaviors and needs, and the survey scores. The data was captured in single audio recordings following the steps of the protocol.

The data from the audio recordings was transcribed to text to be coded in themes, or "nodes", using Nvivo Pro 11. With these themes, the ideas of the participants were categorized as behaviors and needs. Observed associated behaviors reveal the capacity of the empathic experience at recreating the impairments. While latent needs derived from the needs portion provide an indication of the overall effectiveness of the method.

The results of the surveys were collected and summarized in score averages. Unlike the themes, the survey scores apply to all the participants. The following sections present the qualitative and quantitative summaries of the results obtained.

QUALITATIVE ANALYSIS

The qualitative analysis included identifying themes to characterize the ideas of the participants. Behavior and needs themes were analyzed in reference to the module in which they were collected. Themes were found by making a thorough search of the interview scripts as described in the data collection section of Chapter 4. These techniques include a specific emphasis on topics that were repetitive, or pervasive, or that in contrast, were contradictory or alternative, see Appendix B. Also, emphasis was made on specific ideas that the participants indicated as being important using expressions such as: "the most important," or "the biggest one."

Behavior Themes

Behaviors were coded from comments made by the participants in references to their perspective of the impairment and from their experience in the simulation. Participants described user behaviors, problems, and challenges as described in the protocol. Their responses correspond to their general observations, experiences, and assumptions from this condition.

Figure 13 shows the count of total behaviors themes including the portions that correspond to unobserved, observed unassociated, and observed associated behaviors. Notice that unobserved themes only appear in the control data.

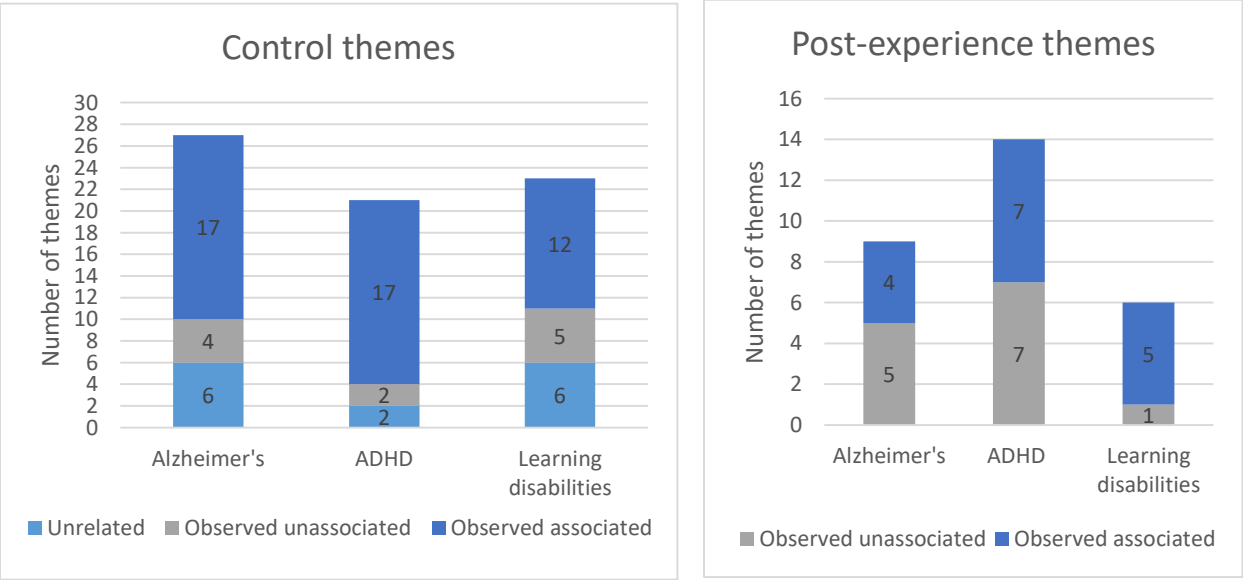

Figure 13. Total Likely Behavior Pre and Post-Experience.

The rest of themes are most likely to be behaviors associated with the formal description of the disorder. It was noted that participants that had direct interactions with individuals with impairment are responsible for the most accurate themes. Overall the number of themes in the post-experience module is smaller. The average number of post-experience observed related behaviors is 5.33 (SD=1.52) across the three impairments, while for the control is 15.33 (SD=2.89). The proportion of observed associated behaviors with respect to the total count is in

average 59.25 % (SD=21.03). This represents a significant decrease from the average proportion in the control of 80.34% (SD=9.45). Also, the proportion of observed unassociated behaviors increases noticeably with respect to the control.

Experience Themes

Experience themes are focused on the participant come from themes can be both concepts that the participants experienced in the simulation, or that they reflected upon when they told their story. For example, participants may have experienced the feeling of "stress," and be encouraged to "prioritize" during the activity. During the reflection questions, they may be telling a story of them finding "confusing" the blue and green color tasks of the Stroop task. So, these themes should be regarded in relation to the participant and the experience.

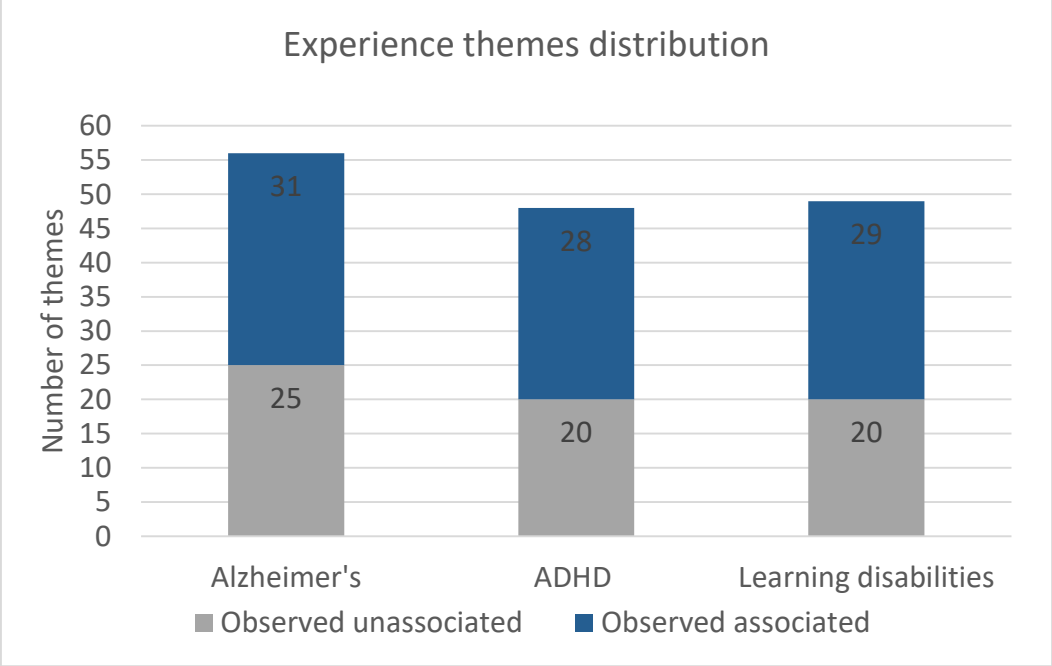

Figure 14. Observed Associated and Unassociated Behaviors in Experience Module

Figure 14 shows the total count of observed associated behaviors and their relative proportion to unassociated behaviors. Observed associated behaviors in this module account for

57.62 % in average (SD=2.01) of the total themes extracted. An outstanding fact about experience themes is that they are significantly large in number as compared to the other data sets. The average number of observed associated behaviors is 29.33 (1.52 SD). Participants spent a significant portion of the interview talking about their experience which resulted in a larger amount of themes.

NEEDS

Needs themes are also focused on the user. This category includes needs expressed in the form of direct solutions with underlying needs, and general needs collected during the need analysis sections Table 4 shows the total count of needs distributed in general and underlying needs.

Table 4. General and Specific Needs

	Control general needs	**Control underlying needs**	**Experiment general needs**	**Experiment underlying needs**
Alzheimer's	25	10	11	15
ADHD	7	25	15	2
Learning disabilities	22	13	15	7
Sum	**54**	**48**	**41**	**23**
Share	52.9 %	47.1 %	64.1 %	35.9 %

This table shows that general needs are represent the majority of themes. In the post-experience module, the share of underlying needs reduces to 35.9 %. The percentage difference between general and underlying needs increased from 5.8% to 28.2 %. This is however, in the big picture, for the Alzheimer's case, there is more specific needs than general ones in the experiment data.

Furthermore, need themes were organized by categories that describe high-level, design parameters and functions. These categories can be found in Appendix C. Table 5 shows a summary of the amount of differentiated needs that were extracted from the larger pool of needs

Table 5. Genera Need Categories

Condition	Pre-experience general need categories	Post-experience need categories	Repeated needs
Alzheimer's	9	9	7
ADHD	6	5	5
Learning disabilities	9	8	4

LATENT NEEDS

From the categories presented before, new needs were considered to define user latent needs. These are the needs that did not fit any other design categories. Table 6 summarizes the total count of needs found in the three study conditions.

Table 6. Possible User Latent Needs

	Possible latent needs
Alzheimer's	-Feedback -Multi-purpose
ADHD	None
Learning disabilities	-Recorded notes -Provide encouragement -Adaptability
Sum	5

A total of five potential user latent needs were extracted. In learning disabilities, there were four new need categories, however, one of the need categories had a high amount of participants reporting the need, which disqualifies it from being a latent need.

ANNOTATIONS ON GENERAL REACTIONS OF PARTICIPANTS

During the experiment it was noted that participants became cognitively active during the control and experience portion of the experiment. Later, however, their energies seemed low when answering post-experience interview. Some of them seemed frustrated when they realized that they were being asked the same questions again.

SURVEY RESULTS

The surveys present the rating of the cognitive abilities based on their perception. Every one of the three interventions collected this information. All questions in survey are graded on an 11 options (0-10) Likert scale ranging from very impaired or not-affected, to very enhanced, affected. Option five was neutral. And questions number four was an open ended question. Table 7 summarizes the results of the survey questions and Table 8 shows the results of the t-test paring.

Table 7. Survey Results

Survey	**Intake Survey**			**Post control survey**		**Post-experience survey**	
Question	**1. Average cognitive skill?**	**2. Immediate cognitive skill?**	**3. Past event influence?**	**1. immediate cognitive skill?**	**2. Control influence?**	**1. Empathy gained?**	**2. Current cognitive skill?**
Mean	8.07	7.90	3.60	7.97	3.03	7.33	6.10
SD	1.08	1.31	4.12	1.23	3.04	3.18	2.64

Table 8. Paired Questions

Questions		**p-value**
Q 1 Intake survey	Q 2 Intake survey	0.58
Q 2 Intake survey	Q 1 Post-Control survey	0.79

The first and second question of the intake survey were paired, as well as question two of the intake survey (8.07 mean, 1.08 SD) with question two of the post control survey (7.9 mean, 1.31 SD). The first pair presents the change in the cognitive skills of the individual from normal conditions to the moment when participants began the protocol ($p<0.58$). The second pair, shows the change that occurred after the control module ($p<0.79$). Neither pair shows a significant difference.

Question three and four asked participants if there had been a recent event that had affected their cognitive abilities. 46.7 % of the participants reported being affected by a previous event while the rest did not. The average score of question three was 3.6 (SD 4.12) which under the option of somewhat affected. Most of the participants reported having had a stressful week, since the experiment was conducted during the last weeks of the semester. Participants also reported being tired in anticipation for their exams, while others reported suffering sleep deprivation.

Question two of the post control survey explored whether the control module had affected their cognitive skills. The average 3.03 (3.04 SD). In this questions, some participants commented that reviewing the case had enhanced their cognitive skills. They mentioned that having to think about the condition made them more cognitively active.

Question number one, of the post control survey, asked participants about their perceived gain in empathy with individuals. Most participants reported having experienced a mild to a high improvement in their ability to empathize. The average score was 7.33 (3.18 SD).

The second question of the post experiment survey sought to verify the effect of the empathic experience on the cognitive abilities of the participants. The average was 6.10 (SD 2.64). This question and questions two of the intake survey were intended to be paired, however, there was an error in the composition of the question that compromised the reliability of the pairing.

Chapter 6: Discussion

The results from the experiment will be analyzed with respect to the last two study objectives. On the one hand, the results of the interviews and survey serve to describe the quality of the empathic experience. On the other hand, the results of the needs analysis provide the validation of the effectiveness of EED-CI at extracting user latent needs. The success of the two objectives will be discussed in the following sections.

EMPATHIC EXPERIENCES

The results of the empathic experience showed a positive effect on participants at creating empathy by closely recreating the condition of impairment. The distinction made between associated and unassociated behaviors serves to understand whether the participants experience the behaviors described in the impairment summaries. The themes in the experience and post-experience modules attained a proportion of 59.25 and 57.62 % of observed associated behaviors. Almost two out of three behaviors corresponds to the descriptions of the conditions.

In contrast, the empathic experience helped participants discover more observed associated behaviors at 29.33, an increase of 14 themes in average. This larger number also kept a similar proportion with respect to the general count 57.62 %. It is outstanding that the participants experienced far more behaviors during the experience but did not reported them in the post-experience. There was a decrease of these behaviors both in number and in proportion. The average number of observed associated behaviors decreased by 23.97 themes in the control to 5.33. The smaller number of themes may be related to two principal causes.

The first cause may be related to the preference of the participants to summarize their comments as they already had expressed in greater detail their insights during the experience exploration. It is possible that the participants did not want to repeat the topics they had just

described. They could have been summarizing their comments. Also, during the experience exploration, participants had the freedom to talk about their ideas, as opposed to the other modules where they had to empathize with other individuals. The second cause for this discrepancy may be related to their level of creativity at the moment of completing the post-experience module. When participants were asked whether the empathic experience had affected their cognitive abilities the average was 6.1 (2.64 SD). Apparently, participants were cognitively strained.

The most accurate observations came from participants that observed directly individuals with impairment. These participants were more accurate at identifying symptoms and behaviors. In contrast, participants that did not observe these conditions in real life were often biased by general perceptions of cognitive impairment. E.g. some of these participants confused hyperactivity with learning disabilities, and Alzheimer's with schizophrenia.

EMPATHY GAINED VERSUS PERCEPTION OF PARTICIPANTS

In general, participants changed their perspective from an arbitrary perspective to a perspective more concerned with the emotional reactions and challenges of the user. This change in perspectives reflects the impact that the empathic experience had in their perception. Question number one of the post-experience survey shows that participants overall felt more empathic with the users (7.3 mean, 3.1 SD) with their average score falling in the "enhanced" or above average option. Participants perceived that their level of empathy definitely improved at some level. It is possible that the experience may not have been fully immersive. This observation comes to mind after considering that the experiment was conducted in the relatively isolated environment of a laboratory without a product interaction. For example, one participant expressed his disagreement by saying "I don't feel what they feel, I feel that my brain is competent. I have compassion but not empathy." So it may be possible that the simulation may not have been sufficiently succinct as to

encourage the participants to articulate well defined insights about the impairments. However, the data shows that they experienced a good amount of associated behaviors, and they also perceived an overall improvement in their empathy.

Then, the experience was more similar to a priming situation than a full immersive experience. For example, while the participants were exposed to an artificial impairment, they were not able to interact with another individual during the simulation. This laboratory condition was not successful at replicating conditions found in the real world. The full method implementation should considered conducting the experiment in an actual user scenario following the main principle of empathic design which suggests visiting the user's real world environment.

NEEDS

In regards to needs, the third objective sought to facilitate the extraction of latent needs. These latent needs would be extracted from those needs that were significantly different from the general pool of needs extracted in both the segments needs analysis. The expectation of an increment in latent needs comes from the hypothesis that the post-experience needs analysis will be able to create a bigger amount and a richer variety of needs. The empathic experience to expose the participants to different situations. However, in spite of participants describing many of the behaviors from the impairments, after experiencing them themselves, the needs that they reported remained similar to the ones in the previous module. In the post-experience needs analysis there were fewer needs extracted (63 total count) in comparison with the control (102 total count). In addition, most of their solutions were either inherited from the control section, or complementary to the same ones. Only a handful of new solutions was obtained in the post-experience portion.

This effect, however, is not entirely surprising. Participants were expected to lack the skill of designers, even though the great majority of them were graduate engineers. A possible cause

might be that participants did not complete the process of reflection. When participants were asked "what would you do to address these issues/the challenges that you mention? Some made comments like "I don't know how you could fix that, that's a good one." Most of their solutions were based on other solution from the control module. During the story reflection, one of the participants with a background in psychology mentioned "If I don't know an answer, I try to look for someone that has the answer and work with them" Therefore, experiencing the impairments and reviewing the information may be less effective at generating needs if they are not complemented with a reflection stage.

Moreover, it is important to consider that this exercise was not the full implementation of EED-CI. A couple of elements that were missing would be a product interaction, and the process of reflection and solutions generation. As the focus of this study was placed on evaluating the experience, participants did not interact with the products that they were trying to redesign. One participant mentioned "I am not sure [of what they need]. It would be easier if I met them in real life. You are asking me about a person that I have never met". People that are not designers don't come up with solutions unless they see a need for it. This may be another cause of the smaller amount of needs recorded.

A complementary explanation may be related with the level of creativity that the participants had after the empathic experience. Where the obvious expectation would be that the participants could become more creative after the empathic experience, they may actually have felt discouraged to create more ideas after reviewing the whole prior section of the protocol. By the time participants had to express the needs that they saw as a result of the experience, they had already spent close to 30 minutes in a highly active cognitive activity. As stated before in the results section, it was noted in the results, participants were somewhat reluctant to answer the

questions that they had already answered in the control module that had exhausted all of their solutions. Often times, during the experimental modules participants would mention phrases like "As I said before," or "Like in my previous answer." Also, participants did not perceive a significant change of their cognitive skills during the control module as seen in the paired value of scores in the control survey question about the rating of their cognitive skills ($p<0.58$). While a similar question of the post experience survey shows that participants had been significantly affected cognitively by the previous activities in the module (6.10, SD 2.64). Overall this may have resulted in a smaller level of creativity. This problem could have been corrected by conducting the control and experiment portions in separate groups.

This last observation is also related to the amount of general versus underlying needs. In the experiment, the proportion of general needs increased to 64.1% in the post-experience module, up from 52.9% in the control one. This change indicates that the participants began to think on a higher level where they trying to address concepts relatively more abstract. This effect may be related to the reasons previously mentioned. Specially to the lack of an actual device that they could examine with attention to details. On the other hand, this increment in general needs may also be reflecting the condition of priming.

LATENT NEEDS

Provided the definition used to select user latent needs, a total of 5 possible latent needs were extracted, 2 from Alzheimer's, 3 from learning disabilities, and none from ADHD. Literature shows that far fewer latent needs are usually identified than direct needs [6]. The extraction of these latent needs provide an early indication that the EED-CI method is capable of generating significantly different new needs that can potentially include latent needs. However, these results are still partial. The method still needs to be fully implemented.

It is also noted that the analysis method employed to extract these latent needs does not considered analyzing in depth the direct needs that were also highly and could potentially be considered original needs. This difficulty is enhanced for the current inability to distinguish between the needs that may have been inherited from the control module. For this reason, it is also recommendable that the experimental needs analysis be completed separated from the control segment.

During the implementation of the full EED-CI method, a critical part will be the inclusion of product interactions, and the completion of the reflection and solution generation steps. These steps from the method should be the most successful at creating new and well differentiated needs. It is also recommended that these portions are completed by proficient designers with strong skills at creating solutions. Since the focus of this future study will be on the design aspect of the method, the control may also be adjusted to fully implement empathic design, and probably lead users analysis.

INTER-RELIABILITY CHECK

The inter-reliability check (presented in Appendix B), shows that work is still needed to ensure that the process to identify themes is accurately reproduced. The check was conducted by allowing a UTEP graduate researcher to process the extraction of themes from four segments of data corresponding to behaviors and needs from pre and post-experience portions. The researcher had no prior experience extracting themes and completed the task using the method outlined above in the data analysis section from a selection of de-identified data. The result in Appendix B show a comparison of the themes extracted from the same subset of the data by the researcher and the main investigator. The analysis was done by comparing the similarity and number of themes extracted. Themes are considered similar if they used the same words, were synonyms, or were

significantly related. Overall, an average 52% (SD=13.1%) of the themes were similar between the ones identified by the researcher and the ones identified in the study. Indicating that nearly one in two themes extracted could be interpreted differently. Furthermore, the number of themes identified varied in the four segments. However, the variability in count does not show an inclination for one party to generate more themes than the other.

A likely cause for these differences is that themes extracted in the study were processed by one single person. Therefore, this individual interpretation may cause difficulties to reproduce the results accurately. Also, the volunteer researcher only had one piece of information to define topics, which probably encouraged him to use criteria with an emphasis on specific observations to define behaviors and needs. In contrast, the study themes had been influenced to account for the generalization of themes across the three conditions. Therefore, it is necessary to conduct a further analysis on the process used to extract themes in order to assure a higher level of replicability

FUTURE WORK

The most significant portion for future work is to continue with the full implementation of a design exercise utilizing the EED-CI method. This future study will be focused on examining the quality of needs generated from the method. It also will need to be completed contemplating that the participants must have a product interaction during the experiment. It is recommended that the full implementation of EED-CI is compared against another full method like empathic design, or user needs analysis.

In addition, a general recommendation is to reformulate the study with two different groups of participants to conduct the experimental and control modules. This would reduce the amount of data points per disability, however, it would increase the precision and accuracy of the data. Another step to take is to focus the experiment on one single case study in order to enable a better

ability to obtain conclusions from the data. The impairment of ADHD would the most beneficial condition to create an accurate empathic experience. ADHD has better defined behaviors as opposed to learning disabilities which has multiple causes that may or may not be directly related to the individual's cognitive skills. Likewise, Alzheimer's tends to create random impairments that may be case sensitive. However, it is important to take into consideration that during the needs analysis it was found that ADHD did not produce possible latent needs. Such a future study needs to determine whether the advantages of a well-defined simulation can result in the identification of new latent needs for this condition.

A further inter-reliability process is also needed to ensure the replicability of the extraction of themes and classification. The current inter-reliability analysis reveals that there is significant variability in terms of the number and similitude of the themes extracted by a different researcher, which represents a low level of precision. Therefore, a more in depth analysis of the procedure used in the data analysis is required to assure an acceptable level of reliability.

Chapter 7: Conclusions

In conclusion, after reviewing the points of discussion, the study was completed successfully as the objectives presented at the beginning were accomplished.

The first objective was successful at creating a novel method to create empathic experiences for multiple cognitive conditions. This method is still able to provide flexibility to incorporate changes or different configurations thanks to the design framework that was used in its construction. This method also provides a more specific solution for designers that seek a step by step guide to utilize the empathic experience approach to empathize with lead users.

The empathic experiences were successful at recreating the conditions of the impairment. The results reveal that many of the associated behaviors described in the conditions were also reported directly from the experience. However, it is not entirely clear if the observed behaviors that were not associated to the impairments could play a role in the identification of latent needs.

Finally, the EED-CI method was also relatively successful at addressing latent needs. A handful of latent needs were extracted even as the full method was not implemented. This early evidence suggests that the full method has the potential to significantly improve the extraction of latent needs. A future study will be required to accurately verify the effectiveness of EED-CI at extracting user latent needs.

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Appendices

APPENDIX A. SELECTED PEBL2 COGNITIVE ASSESSMENTS.

Tests	**Skills**	**Run time**
BART	Decision making, risk assessment,	2:14
Fitt's law test	Hand eye coordination, fine motor skills, concentration	5:24
SNARC	Working memory, concentration, attention, inhibition, numerical processing	6:20
Clock test	Selective attention	2:00
Digit span	working memory, numerical processing, short term memory	2:46
Free recall	Short term memory, reaction time, attention	2:44
Go/No-go task	Inhibition, reaction time, language processing, selective attention	9:40
Implicit association test	Recognition, working memory, association	9:46
Letter-digit substitution	language processing, numerical processing	3:15
Lexical decision	linguistic processing, language processing	1:16
Match to sample task	Reasoning, calculating, color-processing	4:37
Math processing	Mathematical processing, numerical processing, reaction time	10:00 +
Math test	A series of mathematical operation	3:34
Matrix rotation	Selective attention, working memory, visual processing. Reasoning, visual processing, decision making	3:26
Memory span (visual)	Working memory, short term memory, visual processing	4:54
Oddball Task	Inhibition, selective attention, visual processing, reaction time	3:00

Pattern comparison test	Calculating, visual processing	7:44
PEBL Perceptual Vigilance Task (PPVT)	Reaction Time, Attention, Concentration	16:00
Ptracker	Eye hand coordination	2:08
Pursuit rotor task	Hand eye coordination, fine motor skills, strategy and problem solving	1:49
Rotation	Visual processing, selective attention	5:00
Simon Task	Color processing, inhibition, visual processing, selective attention, reaction time	4:00
Spatial cueing	Selective attention, inhibition	6:46
speed taping test	Fine motor skills	3;00
Symbol counter task	Reaction time, working memory, selective attention	4;00
Time wall	Reasoning, calculating, reaction time, strategy and problem solving	4:00
Two columns	Mathematical processing	5:00
Word fluency test	Language processing,	5:00

APPENDIX B. THEMES IDENTIFICATION PROCESS EXAMPLE AND INTER-RELIABILITY CHECK

Selection of Themes.

Following the steps outlined in the data analysis section, the following example shows how need and behavior themes were selected and classified.

Step 1. Transcription For this example let us take into consideration the following paragraph that was extracted from one of the participant's responses in the module of post-experience. The paragraph corresponds to the portion where he describes the behaviors of the user.

Question:

> Considering the experience you've just had, what challenges do you think individuals who have this condition might experience?

Answer:

> *I think it would be very frustrating because it like no matter how much you want to try to just focus on somethings you want to stay focused on during the day you'll just get distracted very easily by something without you wanting to. And it like you feel like you have no control over your own mind. So I think maybe frustrated or even a little afraid. Like a little nervous because you might make a mistake without even catching it. And uh I would feel very like critical like I would want to make sure that I like take precautions when I go out and drive and the go to school and then while I'm taking a test or something that I'm not really focused as much as I can be on doing on performing the task correctly then not doing anything subconsciously or letting myself stray from the what I'm trying to focus on doing. And uh so that's how I think someone would feel like frustrated and a little bit nervous.*

Step 2: Theme identification and labeling Themes are defined by looking for topics that appear with certain frequency, as well as topics that contradict those themes. For this example, the topics that are repetitive are highlighted in color

> *I think it would be very frustrating because it like no matter how much you want to try to just focus on somethings you want to stay focused on during the day you'll just get distracted very easily by something without you wanting to. And it like you feel like you have no control over your own mind. So I think maybe frustrated or even a little afraid. Like a little nervous because you might make a mistake without even catching it. And uh I would feel very like critical like I would want to make sure that I like take precautions when I go out and drive and the go to school and then while I'm taking a test or*

something that I'm not really focused as much as I can be on doing on performing the task correctly then not doing anything subconsciously or letting myself stray from the what I'm trying to focus on doing. And uh so that's how I think someone would feel like frustrated and a little bit nervous.

The labels include a term to describe the general observation (e.g., inability, tendency, lack, stress), and, if needed, a few details to specify the direction of the observation (e.g., to complete tasks, to focus). Therefore, for the themes previously identified the labels would come a follows:

Color	Theme	Sources
	Frustration	3
	Inability to focus	4
	Tendency to be distracted	2
	Afraid	2
	Nervous	2

Step 3. Themes Breakdown This step serves to differentiate behavior and needs themes. For the most part it is self-explicit because the behavior themes are allocated to the portions of the protocol when the participants are asked to describe behaviors and likewise for needs. Since the prior example was extracted from the behaviors exploration segment of the post-experience module, all of these themes are processed as behaviors.

Step 4. Behavior Themes Classification Behavior themes then were filtered to determine behaviors associated to the impairment. This classification of behavior themes pursues to exclude behaviors that are not akin to the general definition of the condition. For this example, "frustration," "afraid," and "nervous" are not associated directly with the impairment, therefore, they are labeled as observed unassociated behaviors. This example, however, does not contain "unobserved" behaviors that occur in the control module only. A couple of unobserved behavior examples are "irritability" and "lack of self-confidence". Following this process, the observed associated behaviors would be:

Theme	Sources
Inability to focus	4
Tendency to be distracted	2

These themes are of special interest because as they were observed, they are more representative of the condition. However, these observed unassociated themes can also be useful at the moment of defining needs. This last part is reserved for the full implementation of the EED-CI method.

Step 5. Needs Classification For this step, consider the following list of need themes from the same ADHD condition:

#	Needs	Sources	References
1	Help their concentration	3	3
2	Auditory engagement	2	5
3	Avoid adding too many options	1	4
4	Avoid being straight forward	1	1
5	Avoid distractions	1	6
6	Avoid making it boring	1	1
7	Avoid pop-ups	1	1
8	Basic fonts and colors, simplicity	1	3
9	Control their access to other applications	1	3
10	Engaging their senses	3	6

From this sample themes, it is visible that some of the themes describe specific solutions. Themes number seven through nine provide direct design solutions because they do not allow additional possibilities for solutions. These solutions must therefore be responding to underlying needs. These three themes can be related to need number 5, avoid distractions. In order to classify these needs, general design categories are created that include as many individual needs as possible.

#	Needs	Sources	References	Need classifications
1	Help their concentration	3	3	Engagement
2	Auditory engagement	2	5	
10	Engaging their senses	3	6	
3	Avoid adding too many options	1	4	Avoid distractions
5	Avoid distractions	1	6	
4	Avoid being straight forward	1	1	Non boring
6	Avoid making it boring	1	1	

These general design categories represent the differentiated needs that the participants are alluding to.

Step 6. Latent Needs Identification. By understanding these differentiations, it becomes easier to compare the needs that are repeated to the ones that are original. The different needs available provide a clue for the latent needs. The following example shows the need categories comparison for learning disabilities. It is possible to notices that only four need categories were unique from the post-experience module. However, the category of "Notes organization" contains three sources, meaning that it has been referenced by three different individuals. This characteristic suggest that the need may actually be more predominant than the rest and, therefore, excludes it from being a latent need.

Learning Disability Need Categories

Pre-experience module				Post-experience module		
Categories	Sources	needs		Categories	Sources	Needs
Sensory isolation	1	1	Repeated categories	Sensory isolation	2	1
Battery life	1	1				
Connectivity with other devices	3	2				
Practical	4	2		Practical	3	4
Austerity	3	2				
Training	3	4		Training	3	2
Multi-purpose	3	5				
Aesthetics	2	1				
Help from others	2	3		Help from others	3	1
			New categories	Notes organization	3	3
				Recorded notes	2	2
				Encouragement	2	2
				Adaptability	1	1

The resulting need categories are identified as latent needs.

Inter-Reliability Check

In order to check the accuracy of these results a small inter-reliability check was performed. A UTEP graduate researcher volunteered to conduct the process of themes identification following the steps previously described. The results of this check are presented below:

Inter-reliability check themes	**Study themes**	Count of themes: Check Study Similar Themes (%)
Control behaviors		
Emotional Outburst	Frustration	5 7 4/7 (57 %)
Lack of focus	Inability to focus	
Medicated	Inability to complete tasks	
Time management	Tendency to be distracted	
Unpredictable	Erratic behavior	
	Inability to be follow instructions	
	Perceived as being rude by others	
Control needs		
Accessibility	Interface	5 4 3/5 (60 %)
Functions	Avoid adding too many options	
Graphics	Avoid distractions	
Interface	Guide their distractions	
User interaction		
Post-experience behaviors		
Emotional outburst	Frustration	4 5 3/5 (60 %)
Lack of focus	Inability to focus	
Self conscious	Tendency to be distracted	
Uncontrollable	Nervous	
	Afraid	
Post-experience needs		
Content	Avoid making them feel like a strange person	3 3 1/3(33 %)
Display	Give them rewards	
Management	Control their notifications	
Average percentage of similar themes		**52.5%**

The inter-reliability check shows that the themes selected by both parties share some level of commonality. However, this level is evidently quite low. The check shows that further steps need to be taken to assure that the process of identifying themes is well communicated so that it can be replicated. The areas of disagreement include the focus of the themes, and the number of themes used.

APPENDIX C. NEEDS CATEGORIES

Alzheimer's Need Categories

Pre-experience module				Post-experience module		
Need categories	Sources	Needs		Needs categories	Sources	Needs
Interface	4	7	Repeated categories	Interface	1	1
Remote assistance	5	7		Remote assistance	3	5
Supplement memory	4	5		Supplement memory	5	6
Size	1	1				
Regulate emotions	3	4		Regulate emotions	4	5
Discrete appearance	3	4		Discrete appearance	1	1
Cost	1	1				
Durable	3	5		Durable	3	3
Secure	5	1		Secure	2	2
			New categories	Feedback	1	1
				multi-purpose	3	3

ADHD Need Categories

Pre-experience module				Post-experience module		
Needs categories	Sources	Needs		Need categories	Sources	Needs
Avoid distractions	3	4	Repeated categories	Avoid distractions	1	1
Monitoring their activity	2	3		Mentoring	4	9
Rewards	2	1		Rewards	2	2
Mentoring	4	6				
Non boring	2	2		Non boring	2	3
Engagement	5	9		Engagement	1	1

*No new categories.

Learning Disability Need Categories

Pre-experience module				Post-experience module		
Categories	Sources	needs		Categories	Sources	Needs
Sensory isolation	1	1	Repeated categories	Sensory isolation	2	1
Battery life	1	1				
Connectivity with other devices	3	2				
Practical	4	2		Practical	3	4
Austerity	3	2				
Training	3	4		Training	3	2
Multi-purpose	3	5				
Aesthetics	2	1				

Help from others	2	3		Help from others	3	1
			New categories	Notes organization	3	3
				Recorded notes	2	2
				Encouragement	2	2
				Adaptability	1	1

Curriculum Vita

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