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Driver Training Application for Individuals with Autism

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Abstract

Compared to their peers without autism spectrum disorder (ASD), individuals with ASD are more likely to be underemployed and engage in fewer academic and social pursuits. A barrier may be the lack of independence in driving. A usability evaluation of a driver training application, Drive Focus, was conducted. Four rounds of subjects evaluated the application. The rounds alternated between neuro-typical teens and teens or young adults with ASD. There was a decline in the number of comments made within each subject group, suggesting that the iterative process was effective in refining the App. An important component of this work was the utilization of a subject matter expert; in this case, an occupational therapist was part of the usability team.

Keywords: quality improvement, automobile driving, Autism spectrum disorder

Introduction

The transition years into adulthood can be challenging for individuals with autism spectrum disorder (ASD). While most young adults are actively engaged in academic, vocational, and social activities, the majority of individuals with ASD are disconnected. Approximately two-thirds of individuals with ASD in their early 20s are neither employed nor involved in academic pursuits, and one in four are socially isolated (Roux, Shattuck, Rast, Rava, & Anderson, 2015). For young adults with ASD, a barrier to participating in these and other community-based activities may be lack of independence in community mobility, a skill typically achieved in teenage years.

Among all forms of community mobility, Americans are most dependent on the personal automobile (U.S. Department of Transportation, 2015). The ability to drive is a basic skill required to engage in community-based activities, making driving literacy as essential as computer, health, or financial literacy. However, the act of driving is complex, requiring the efficient coordination of sensory, motor, and cognitive skills including executive function skills (Classen, 2010). Individuals with ASD may experience challenges in all of these domains (Classen, Monahan, & Hernandez, 2013). ASD is a common developmental disability affecting one in 59 U.S. children. Of the individuals with ASD nearly half (44%) are classified as having high-functioning ASD and therefore do not have a cognitive disability (Baio et al., 2018). However, individuals with high-functioning ASD may experience difficulty with higher level cognitive skills such as executive function in the areas of divided attention, attention shifting speed, prioritization, inhibition, working memory, and planning (Hill, 2004; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006). Despite these challenges, approximately one in three teens with high-functioning ASD will become licensed drivers, a rate substantially lower than that of their neurotypical peers (83.5%) (Curry, Yerys, Huang, & Metzger, 2017).

Studies suggest that learner and licensed drivers with ASD may make more driving errors than their peers without ASD (Classen et al., 2013; Daly, Nicholls, Patrick, Brinckman, & Schultheis, 2014). Complex driving situations that increase cognitive demands may cause drivers with ASD to have delayed responses to hazards and increased driving errors (Daly et al., 2014; Reimer et al., 2013). The ability of individuals with ASD to recognize and respond to roadway hazards has been the topic of a number of studies. Sheppard, van Loon, Underwood, and Ropar (2016) found that participants with ASD took longer to visually locate a hazard in videos of roadway scenes. Reimer et al. (2013) found that licensed drivers with high-functioning ASD tended to avert their visual gaze away from hazards when driving a simulator. Classen et al. (2013) found that non-drivers with ASD made more adjustment to stimuli errors (not responding to changes in the environment) on a driving simulator compared to their neurotypical peers.

Multiple studies have identified a need for specialized driver training for the ASD population (Almberg, Selander, Falkmer, Ciccarelli, & Flalkmer, 2015; Classen et al., 2013; Cox, Reeve, Cox, & Cox, 2012; Daly et al., 2014; Reimer et al., 2013). Training can require three times as many lessons as novice drivers without ASD (Almberg et al., 2015).

A Certified Driver Rehabilitation Specialist (CDRS) is a professional who provides specialized driver training for individuals with medical conditions. There are approximately 370 CDRSs in North America, the majority of whom are also occupational therapists (OTs) (The Association for Driver Rehabilitation Specialists, n.d.). The inadequate number of professionals to meet the demands suggests a need for intervention tools that do not require the oversight of a CDRS. Unfortunately, there is a lack of evidence-based intervention tools for learner drivers with ASD to use with or without the oversight of a CDRS (Classen & Monahan, 2013).

There is evidence to support the use of technology and particularly video-based technologies to teach individuals with ASD life skills such as self-care, social, and vocational skills (de Bruin, Deppeler, Moore, & Disamond, 2013). When surveyed, 67% of the parents of novice drivers with ASD identified that technology-based programs may be beneficial for teaching their child to drive (Cox et al., 2012). It is thus conceivable that a video-based technology may help individuals with ASD learn driving skills.

Beyond a technology platform, a driver-training tool designed for individuals with ASD should consider instructional methods that support comprehension, a key pillar to literacy. A learner's comprehension can improve when evidence-based learning preferences are integrated into instructional methods (Schoonover & Press, 2019). For example, integrating visual information (e.g., pictures and videos) is helpful for the ASD population to learn new skills (de Bruin et al., 2013; National Institute for Health and Care Excellence, 2013). Because people with ASD have a tendency to interpret language literally, it is best if language is free of potential ambiguity. People with ASD benefit from routine and structure when participating in activities (National Institute for Health and Care Excellence, 2013). The integration of structure and predictability within a technology may positively influence learning. Lastly, individuals with ASD tend to have more difficulty transitioning skills to new environments. Implementation of strategies that allow individuals with ASD to recognize the similarities between environments helps generalize skills to new environments (National Institute of Mental Health, 2011).

A prototype application for the iPad®, Drive Focus®, was conceptualized by an OT CDRS to address the gap in driving related training tools for individuals with ASD. The specific objective was to design an application to improve visual search skills and hazard recognition. The user learns to identify critical information such as speed limit signs, traffic lights, vehicles, and pedestrians, using a systematic method. The app utilizes an innovative interactive-video technology (not animation) that allows the user to touch on critical information, such as a red traffic light, and receive feedback with simultaneous auditory chimes and visual halos around the object to signify a correct response or an error. The method of training teaches the user to touch on the critical information in order of its priority (e.g., touch the red light before the speed limit sign). If the video is moving too fast for the user, they can slow down the video through the use of three video speed choices and gradually increase the speed of the video as they improve (Drive Focus, 2019). The Drive Focus videos are organized into three levels of complexity where the user navigates through the levels of complexity, increasing in difficulty after attaining a score that unlocks the next level.

To improve the user's experience with products, developers and manufacturers ideally incorporate a usability process at the prototype phase. A usability process may include a heuristic evaluation followed by a usability evaluation (Nielsen, 1993). A heuristic evaluation is conducted by a small number of professionals who typically specialize in human factors and ergonomics (Nielsen, 1993). During a heuristic evaluation the technology prototype is reviewed by the professionals to assess whether it incorporates usability principles. There are five overarching usability principles that a product should incorporate. The product should 1) be easy to learn, 2) be efficient to use once it is learned, 3) be organized logically so that it makes it easy to remember when reengaging with the product, 4) produce minimal user errors, and 5) be pleasing to use (Nielsen, 1993; usability.gov, 2014). Once the heuristic evaluation is completed it may be followed with a usability evaluation.

A usability evaluation further assesses how well the prototype upholds the usability principles when tested with a specific user group or groups (usability.gov, 2014). An iterative testing design is an example of how the prototype may be tested: A group tests the technology prototype, the manufacturer refines the product based on the feedback from the first group, and another group tests the product (Mayhew, 1999). The process should be repeated until the majority of issues are resolved (Mayhew, 1999). A common approach to the iterative design is to observe the user interacting with the prototype while the user "thinks aloud" to verbally state their thoughts and opinions (Nielsen, 1993; usability.gov, 2014). The observations help identify what the user is doing and the think-aloud process helps illuminate why the user is doing what they are doing, and gathers their opinions about the prototype (Nielsen, 1993).

The purpose of the current study was to conduct a usability study on the Drive Focus prototype to ensure the app meets usability guidelines as well as the learning preferences of the ASD population to improve driving literacy.

Target Audience and Relevance

This work is of relevance to both developers of assistive technology products and professionals who work with individuals with ASD. For developers, the work illustrates how the usability process can improve literacy of a subject, in this case driving among the ASD population. The process allowed for refinement of the application to support key elements for achieving literacy: engagement (user satisfaction) and comprehension (ease of learning). In addition to the expertise of a usability team, this work highlights the importance of using a subject matter expert (e.g., OT-CDRS) to integrate instruction methods that support driving and the learning preferences of the ASD population. For professionals working with the ASD population, this work also describes the challenges that individuals with ASD may experience when learning the rules of the road and how technology may help overcome these challenges.

Methods

Prior to initiating this usability evaluation, three rounds of heuristic evaluations took place. These were conducted by a human factors psychologist and two research assistants that are part of the usability team at Clemson University. The Drive Focus team revised the app based on the feedback from the heuristic evaluations before starting the usability evaluation. The Drive Focus team included the OT CDRS, the project manager, app development team, and a graphic designer.

Design

The usability evaluation involved an iterative process of a set of participants testing the Drive Focus application (App), reviewing the results, deciding how to address topics that arose, and refining the App. The entire process was repeated again until four rounds of participants evaluated the App. The first and third rounds of participants were neurotypical teens while the second and fourth rounds were teens and young adults with ASD. This alternating rotation between population groups was used to ensure that the revisions to the App were appropriate for both populations: Changes suggested by one group did not negatively impact the other group.

Participants

The usability team recruited 13 neurotypical teens. Five participated in the first round and eight participated in the third round. The inclusion criteria were 1) age > 14 and < 18 years; 2) any status of driver's license (i.e. no permit, a valid learner's permit, or a driver's license), 3) ability to read and understand English; and 4) an interest in learning how to drive or more about driving. Exclusion criteria were 1) diagnosed with a severe psychiatric condition per parent report; and 2) neurological condition such as ASD per parent report. The participants were compensated for their participation with school service-learning credits.

Participants with ASD were recruited from a pediatrics clinic. Table 1 describes the demographics of both groups.

Table 1: Descriptive Statistics on Demographics of Participants Without ASD and With ASD (N = 24)

Variable	Subjects without ASD (*n* = 13)	Subjects with ASD (*n* = 11)
Gender n (%)		
Female	8 (61.5%)	1 (9%)
Male	5 (38.5%)	10 (91%)
Age in years M (SD)	15.2 (1.2)	16.5 (2.3)
Age range	14-18	13-21
Driving History		
No permit or license n (%)	8 (61.5%)	7 (63%)
Permit drivers n (%)	3 (23.5%)	2 (18.5%)
Licensed drivers n (%)	2 (15%)	2 (18.5%)
Grade M (SD)	9.5 (0.9)	10.1 (2.2)
Use iPad/tablet at home	13 (100%)	7 (63%)

Eleven total participants with ASD enrolled in the study. Six participated in the second round and five in the fourth round. The inclusion criteria were the same as the neurotypical subjects with the changes of 1) ages > 13 and < 21 years; 2) have a physician verified diagnosis of ASD, and 3) be in a regular education setting for at least 75% of the school day. The age for the volunteers with ASD is representative of the age group treated at the clinic that asks about driving. The exclusion criterion was a diagnosis of a severe psychiatric condition per parent report. The subjects were not compensated for their participation.

Setting

The first and third rounds were conducted in an office at the school where the neurotypical teens were recruited. In the second and fourth rounds, the testing was conducted at the university.

Equipment and Materials

An Apple iPad Air® MD 786ll/A, the Drive Focus App, and a notebook containing screenshots of the App were used in all rounds. The Apple iPad was in a case that allowed the subject to lay the iPad flat or stand it at different angles.

Drive Focus application. The Drive Focus App (https://drivefocus.com) is comprised of two main sections: a Training section and a Tour section. The Training section provides instructions on the visual search method, interpreting the scores, and how the App operates. The Tour section contains the Vermont Tour with six interactive videos of drives; two low-, two medium-, and two high-complexity drives. The gradation of the drives is based on the amount of stimuli present.

Drive Focus's Training section. There are six subsections included in the Training section: overview, critical items, priorities, scoring, App controls, and tips.

The *critical items* section instructs the user on the 11 categories of critical items to be aware of as a driver. Critical item categories include stop signs, traffic lights, yield signs, regulatory signs, pedestrians and cyclists, brake lights and turn signals, pavement markings, vehicles entering the driver's path, caution signs, construction signs, and objects in the road. As each critical item is introduced, the instructions explain why that item is critical for the driver to notice, see figure 1.

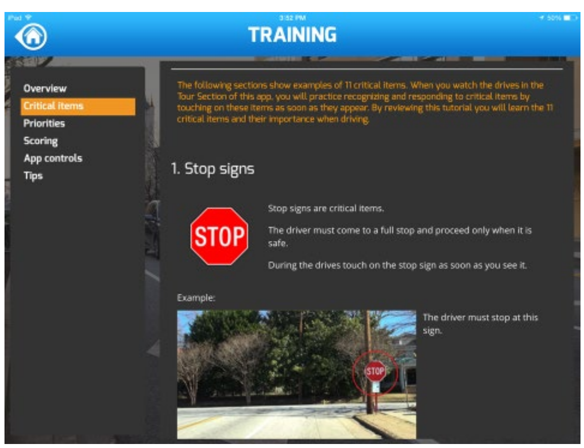

Figure 1: Example of the stop sign in the* critical item *section.
(Drive Focus, 2014)

The *priorities* section instructs the user how to determine what critical items take priority over another.

For example, when approaching an intersection with a green light and the car in front has its brake lights on (both critical items), the brake lights take priority over the green light because the driver may need to slow down or stop. In this case, the user is instructed to touch the brake lights before the green light.

Drive Focus Tour section. The Tour section opens to the Vermont Tour where the user can select a drive (video), see figure 2. The three drives of low complexity are unlocked while the two moderate- and two highest-complexity drives remain locked until an overall score of 500 (50%) or greater is achieved for each respective level. The duration of the drives ranges from three to five minutes.

***Figure 2: Image taken from a moderate level drive in the* Vermont Tour.**

(Drive Focus, 2014)

Notebook. Screenshots were taken of each image of the App and compiled into a three-ring notebook in advance of the testing. The notebook was used by the research assistants to write the subjects' participant number, comments, and the researchers' observations next to the related item on the App. After the App was revised between subject rounds, new screenshots were taken and a new notebook was made.

Procedure

All participants and their parents completed a background questionnaire, consent form, and an assent form. The participants were introduced to the study and instructed on the think-aloud process. To ensure that each subject understood the think-aloud process they were given a paragraph to read aloud that had grammatical and wording errors. The participant was asked to identify the errors as they read aloud. The research assistant marked the errors identified to illustrate the role of the researcher.

The participants were asked whether they use an iPad. If a subject did not have experience with an iPad and demonstrated difficulty operating the tablet, the research assistant provided instruction and assistance with functionality of the tablet. Prior to being directed to the Training section of the App, the subjects were given five minutes to explore the App on their own. After the exploration period, the participants were instructed to proceed through the Training sections reading aloud the text while stating their thoughts. After completion of the Training section, the same instructions were given while the participants interacted with the drives in the Tour section. Throughout the Training and Tour sections, the researchers recorded the participants' comments and their observations in the notebook.

Data entry. Participants' demographic information, comments, and observations from the notebook were entered into Excel spreadsheets by a research assistant who did not collect the data. The research assistants that collected the data verified that the comments/observations were entered accurately and coded correctly with regard to 1) the intention (positive, neutral or negative), and 2) one of six general classifications (grammar, formatting, clarification of words, video, images, or other).

After each round of the usability evaluation, the OT-CDRS examined the data and categorized each comment/observation under 1) a construct (user satisfaction or ease of learning) and 2) a benefit for individuals with ASD (beneficial, neutral, or negative). When the OT-CDRS identified problem trends (e.g., several subjects misinterpreted an App function) or overt errors (e.g., punctuation), revisions to the App were recommended. The OT-CDRS documented the decision making process in the spreadsheets: whether the decision to revise the App involved only the OT-CDRS or required a Drive Focus team discussion. The Drive Focus team was consulted when comments or observation had technical and stylistic implications. The Drive Focus team members provided their suggestions as to how to address the problem trend(s) and the OT-CDRS made the final decision. The OT-CDRS also entered into the spreadsheet a rationale to resolve or not resolve the App based on considering the literature.

Data analysis. This descriptive study summarized the participants' comments and researchers' observations for each round of subjects testing the App. The summary included subcategories of comments such as the intention (positive, negative, or neutral), the classification of the comment (grammar, formatting, wording, video, image, or other), the construct (user satisfaction and ease of learning), and justification (benefits to the ASD population). The justifications of the decisions were based on one of four themes from the literature: 1) visual information, 2) concrete language, 3) structure and predictability, and 4) opportunities for generalizing skills can support the learning preferences of individuals with ASD (National Institute for Health and Care Excellence, 2013; National Institute of Mental Health, 2016). The themes were summed to identify the themes the OT-CDRS relied on most when making decisions. Examples of the comments/observations were used to illustrate the influence of the literature on justifying making or not making a change to the App.

The total number of comments/observations that resulted in a change to the App between each round of subjects and in relationship to justification and construct were summarized. In addition, the number of changes made to the App that was decided by the OT-CDRS versus the Drive Focus team was tallied. Lastly, the number of changes made to the App (multiple comments can lead to a single change) was totaled for each round.

Results

Comments and Observations

The participants' comments and researchers' observations were coded by blind research assistants and further categorized by the OT-CDRS after each round of testing; this information is summarized in Table 2. The total number of comments declined between the initial and final session for each of the participant groups (without ASD and with ASD) suggesting that the iterative process of the usability evaluation was helpful in improving the App, using the evidence of the reducing the numbers of items identified.

Table 2: Descriptive Summary of Comments/Observations by Number and Category per Round

Comments/Observations	**Round One *n* = 5 (Without ASD)**	**Round Two *n* = 6 (With ASD)**	**Round Three *n* = 8 (Without ASD)**	**Round Four *n* = 5 (With ASD)**
Total Number of Comments*	245	125	225	32
Classification of comments/observations*				
Grammar/punctuation/capitalization/ typos	67	23	10	2
Format/bold/color	1	2	3	2
Clarification/word or phrase	104	63	108	14
Video	7	6	35	7
Images	62	12	31	2
Other (can mean multiple categories/general comments)	4	19	38	5
Overall intention of comment/observations				
Positive	41	11	18	1
Negative	32	30	61	13
Neutral	172	85	146	18
Construct				
User Satisfaction	181	91	167	25
Ease of Learning	64	33	58	7
Other	0	2	0	0
Justification				
Beneficial for ASD	16	18	49	6
Neutral for ASD	224	107	151	26
Negative for ASD	5	0	25	0

**Note = coded by research assistant at CU-ICAR versus OT-CDRS*

Each comment/observation was identified by the OT-CDRS as one of three constructs; 1) user satisfaction, 2) ease of learning, and 3) other. The majority of comments/observations were related to user satisfaction and included (a) word changes based on preference versus clarification, (b) the request for less repetition, (c) grammar or punctuation corrections, and (d) general positive comments regarding the experience with the App. Comments/observations related to ease of learning included (a) images did not support the learning, (b) word or phrase were unclear, and (c) positive comments about the information being easy to understand. The “other” category included information that was not representative of the two constructs. Examples of “other” include general comments such as “there are a lot of driving rules”.

If a comment/observation justified making a change or not making a change based on the literature related to ASD, it was categorized as beneficial or not beneficial for the ASD population. All other comments that did not have relevance to the ASD literature were considered neutral. The majority of comments/observation in each round were neutral. More importantly, there were more comments/observations that were beneficial to the ASD population compared to negative as seen in Table 2. Such comments helped improve the App for the ASD population.

Literature and Justification

There were four themes in the literature that guided the decisions by the OT-CDRS as to whether the comments/observations suggested a change to the App that would or would not be beneficial for the ASD population. Table 3 summarized the four themes from the literature, the number of times a theme was applied, and examples of comments/observations related to the theme that would either benefit or not benefit the ASD population.

Table 3: Literature that Supported Decisions by OT-CDRS and Frequency of the Application Across All Four Rounds

Themes from the literature	Resources	Beneficial for ASD population example	Total beneficial	Not beneficial for ASD population example	Total not beneficial
Visual information can support learning for individuals with ASD	(de Bruin et al., 2013)	Comment/Observation: Wonders why there is no yellow light picture Problem: The subsection on traffic lights has green light and red light pictures and text. However, there is no picture of yellow light. Decision: Add picture of yellow light and text to explain importance of light.	Total = 21 comments	Comments/Observations: None	Total = 0 comments
Language that is free of potential ambiguity can support learning for individuals with ASD	(National Institute for Health and Care Excellence, 2013)	Comment/Observation: Is there a reason why you changed construction activity to construction site? Problem: Inconsistent wording Decision: Use construction site throughout	Total = 50 comments	Comments/Observation: Replace "items" with "signs" in "Recognizing…" Problem: Subject prefers signs over items, however not all critical items are signs. Decision: No change	Total = 5 comments
For people with ASD their ability to learn new information may be positively influenced with structure and	(National Institute for Health and Care Excellence, 2013; National Institute of Mental Health, 2016)	Comment/Observation: 1) “Doesn't say what to do here” 2) “Add, what you need to do here.” 3) Add "The driver may need to slow down". Problem: Three comments identify that the subsection on vehicles entering the	Total = 11 comments	Comments/Observation: 1) Doesn't think "stop signs are critical items" is needed 2) Doesn't know if it is necessary to repeat "The driver must stop at this sign", because it is already said Problem: Two subjects complained of repetition	Total = 30 comments

Themes from the literature	Resources	Beneficial for ASD population example	Total beneficial	Not beneficial for ASD population example	Total not beneficial
predictability		driver's path was inconsistent with the structure of other sections where the action of the driver is described. Decision: Added "The driver may need to slow down or stop."		Decision: No change because repetition supports predictability	
People with ASD may generalize skills to new environments when they can recognize the similarities between environments.	(National Institute of Mental Health, 2016)	Comment/Observation: 1) Asks about missing pedestrian sign, 2) Asks the question: "Do I have to let people cross the street if there's no sign?" Problem: Two subjects did not understand what action the driver should take when there are pedestrians crossing without a sign. Decision: Provide text to explain that the driver must yield to pedestrians whether there is a sign or not.	Total =7 comments	Comment/Observation: You have already read about red and green lights in the critical items - seems unnecessary at this point. Problem: The subject was complaining about redundancy from Critical item subsection to the Prioritization subsection Decision: No change, the present wording and example supports generalizing information to a new situation.	Total = 1 comments

Changes to the Drive Focus App

Based on the participants' comments and the researchers' observations, 195 changes were made to the App during the usability evaluation and are summarized in Table 4. The total number of comments/observations that resulted in a change across all four rounds was 259. Multiple comments in some cases led to a single change. Some changes were deferred to the next version of the App because of financial constraints that prevented major architectural changes to the App's technology (e.g., adding interactive videos to the Training section).

Table 4: Changes to the Drive Focus App per Category and Round

Changes made by category	Round One *n* = 5 (Without ASD)	Round Two *n* = 6 (With ASD)	Round Three *n* = 8 (Without ASD)	Round Four *n* = 5 (With ASD)
Total number of comments that resulted in a change	132	32	83	12
Change by justification				
Beneficial for ASD	14	16	35	1
Neutral for ASD	118	16	48	10
Negative for ASD	0	0	0	0
Changes by construct				
User satisfaction	92	12	52	9
Ease of learning	40	20	31	2
Other	0	0	0	0

Changes made by category	Round One *n* = 5 (Without ASD)	Round Two *n* = 6 (With ASD)	Round Three *n* = 8 (Without ASD)	Round Four *n* = 5 (With ASD)
Changes by resolution process				
Decisions made by OT-CDRS	111	24	30	1
Decisions made by Drive Focus Team	21	8	53	11
Total number of changes	127	32	28	8
Made in this revision	123	29	21	0
Changes deferred to next version	4	3	7	8

Outcomes and Benefits

Overall there was a decline in the number of changes made after each participant group tested the App. This suggests that the iterative process was effective in refining the App for changes that the OT-CDRS and/or Drive Focus team considered appropriate. The majority of comments/observations in each round were related to *clarification, word choice, or phrase*. The least number of comments were related to *format, bold, or color*. A noteworthy finding was that there was a decline in comments related to *grammar, punctuation, capitalization,* and *typos* between the initial and final session for each of the participant groups (without ASD and with ASD). For the participants with ASD, there was also a decline in comments between the initial and final session for the *clarification/word or phrase.*

In the usability evaluation of Drive Focus, the participants were asked to identify things that were confusing, frustrating, or incorrect. They were not asked to identify positive features about the App. The fact that participants provided positive comments about the Drive Focus App during each round of testing is a favorable indication of user satisfaction.

This experience suggests that involving a subject matter expert with knowledge in ASD and driving in the design and usability testing of Drive Focus helped ensure that the changes to the product were beneficial to the ASD population. Across all four rounds the OT-CDRS identified 89 comments/observations as beneficial changes for the ASD population; 66 (74%) of those resulted in changes. No changes were made to the App that would knowingly be negative to the ASD population according to the literature.

Discussion

The majority of comments/observations (165 out of 259) that resulted in a change were related to user satisfaction. The changes made to the App to improve user satisfaction included correction of *grammar, punctuation, capitalization* and *typos* errors or replacing *words* or *phrases* based on preference. When a single subject identified a grammatical or punctuation error, the error was corrected. In other cases, the OT-CDRS looked for trends in the subjects' comments/observations before making a change to the App. For example, in the Training section there was a picture of a speed bump with a caution sign and the word "hump". In the text next to the picture, the word "hump" was used to be consistent with the picture. Multiple participants disliked the word "hump" and suggested we use "bump". The word was changed to "bump" after the first round of subjects. No other comments from later subject rounds requested "hump" to be consistent with the picture.

The entire Drive Focus team was involved when decisions to revise the App could have implications with regards to budget, technical architecture, and the visual experience of the App. For example, multiple participants complained that the images of the score output were too small. The team discussed adding a click and enlarge function, but it proved to be too expensive to change the technology architecture. The final outcome was to replace previous images of the scoring with larger images. This would not make the image full screen (like the click and enlarge), but it made the images larger.

Out of the 195 changes made to the App, 93 were made to improve ease of learning. As in the case of the revisions for user satisfaction, the OT-CDRS typically made decisions without consulting the team when the decision required a word or a phrase change to improve ease of learning. For example, participants identified some sentences as being too long and difficult to understand. The OT-CDRS revised the text with shorter, more concise statements. When writing the text, the OT-CDRS applied the concept of keeping language concrete to support the ASD population’s learning preferences (National Institute for Health and Care Excellence, 2013).

Other ease of learning problems identified by the comments/observations required team input. The score output was just such an example. A feature of the score output is a window with a scrollbar that allows the user to view each critical item that appeared in the video scenario and score details related to 1) identification, 2) the selection of priority, and 3) the response time for each critical item. The research assistants observed that a number of participants did not recognize the window as having scrolling functionality. The scrollbar used adhered to Apple specifications (small and slender). Since enlarging the scrollbar or changing the color of the scrollbar was not permitted by Apple, the team explored other options. After searching for similar windows in other apps and creating multiple conceptual diagrams, the team decided to fade the last item of the scroll window, to illustrate that there was more information below. The fading of the last item in the window is used in other products with scroll windows, and therefore makes it more recognizable to the user that it is a window with scrolling functionality.

Subject Matter Expert Collaboration in the Usability Evaluation

The collaboration with the OT-CDRS as the subject matter expert in the usability evaluation was critical for its success. The usability team provided the expertise in planning, recruiting, and implementing the iterative study design as well as the skills for collecting data, while the OT-CDRS provided knowledge on how individuals with ASD perceive and process information. This knowledge was applied when making decisions on whether and how to revise the App. The OT-CDRS routinely considered four themes from the literature when making decisions. The themes identified that the ASD population’s learning preferences typically benefit from visual information, concrete language, predictability and structure, and opportunities to generalize new information.

There was one circumstance where the OT-CDRS needed to consult the literature beyond these four themes before making a revision. Initially, the App was designed with two auditory tones, a chime to indicate the user correctly touched a critical item and a “bonk” sound when the user touched a non-critical item. A few participants commented that a third sound was needed to indicate that the item had already been touched. The Drive Focus team thought that suggestion was a good idea. However, the OT-CDRS was concerned about introducing another sound. The OT-CDRS knew from clinical experience that auditory processing could be a challenge for the ASD population but was uncertain whether this difficulty was associated with discrimination of tones. The literature suggested that individuals with ASD have either typical or enhanced auditory discrimination of tones compared to their peers without ASD (Bonnel et al., 2010; Jones et al., 2009; O'Connor, 2012). However, individuals with ASD can experience hypersensitivity to sounds that are typically loud, sudden, or high-pitched (O'Connor, 2012). Based on the literature, the OT-CDRS decided it would be appropriate to add a third tone, but the tone should be consistent with the volume of the other two tones while being readily distinguishable. The third tone selected was a two-note electronic, low-pitched sound.

Out of the four themes that guided the OT-CDRS’s decisions to revise or not revise the App, the majority (50) were based on the theme that language that is concrete can support the ASD population’s learning preferences (National Institute for Health and Care Excellence, 2013). Given that the Training section has mostly text compared to images or videos, it was not surprising that this theme was used the most. The majority of comments/observations that suggested a change that could be potentially negative for the ASD population’s learning preferences were complaints about the repetition of the instructions to “touch on the specific critical item” whenever they saw it in the Tour videos. The OT-CDRS rejected these suggestions for concern that the ASD population would benefit from the repetition (Foster & Cox, 2013; National Institute for Health and Care Excellence, 2013; National Institute of Mental Health, 2011). There were 30 comments in total that requested less repetition in the Training section; of those, 24 came from the group without ASD and six came from the group with ASD. Thus, the participants without ASD found the repetition less necessary compared to the group with ASD. The OT-CDRS’s decision not to reduce the repetition was to maintain the App in accordance to the ASD population’s learning preferences.

The usability evaluation of Drive Focus was essential for improving comprehension and ultimately literacy of the instructional material. In the case of the Drive Focus App, information from the literature and clinical expertise guided the decisions to revise the App to improve the comprehension and user engagement. However, the participants provided valuable insights that resulted in 195 revisions to the App. The number of revisions underscores the benefits of a usability evaluation even when the developer has strong knowledge of the targeted population.

Limitations and Future Research

Limitations of this usability evaluation includes the lack of detailed demographic information about the ASD participants, such as reading level, and whether medications were prescribed and taken for attention during the session. Future research should be a study to determine how much the Drive Focus App helps individuals with ASD develop visual search skills for driving. It was a pleasant surprise to hear many participants, both neurotypical and ASD, comment, “I did not know that.” It will be helpful to know how much Drive Focus training is needed to have a significant change for the ASD population. For example, does it take two or ten hours before a measurable change occurs. It will also be useful to replicate this usability study for other samples ranging from stroke patients to drivers from different countries who need to gain experience prior to getting behind the wheel of a vehicle.

Declarations

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