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Abstract

The literature has emphasized the positive impact of mobile technologies with augmentative and alternative communication (AAC) apps for enhancing the functional communication skills of individuals with autism spectrum disorders (ASD). Although various AAC apps are available, the system design of such apps presents assorted challenges, particularly for those with ASD in different cultures. Designing useful and engaging apps by considering the affordances of mobile technologies and the characteristics of individuals with ASD may contribute to the success of interventions. In this regard, the purpose of this study is to examine the design specifications of AAC apps based on the considerations of subject-matter experts from an instructional system design (ISD) perspective. The current research employed a design-based research framework, including different methods. An AAC app named as EBA was developed by following design specifications as suggested by the field experts to answer the research questions. The results of the study revealed several enhancements in usability, flexibility, and feasibility issues of AAC apps, and highlighted the importance of (a) personalized apps, (b) simple user-interface, (c) hierarchical representation of visuals, (d) responsive apps, (e) help and documentation, and (f) parent control service. Directions for future research are proposed.

Introduction

Individuals with autism spectrum disorder (ASD) may use augmentative and alternative communication (AAC) to have better communication with other people. AAC interventions generally include different tools (i.e., picture communication cards, low-tech or high-tech communication systems) and methods (i.e., modeling, direct instruction, etc.) to support or replace natural speech (Mirenda 2003; Moffatt et al. 2017). They can facilitate language development in children (Romski & Sevcik 2005), and provide a method to express their needs (Lorah et al. 2015; Mirenda 2003; Romski & Sevcik 2005). The use of AAC is not limited to children, people at different ages can benefit from these systems (Ganz et al. 2017) to request not only an object but also engage in a social activity (Logan et al. 2017).

With the rapid advancements in information and communication technologies (ICTs), there has been an increasing

interest in the adaptation of mobile technologies as a supportive service in the field (Tsiopela & Jimoyiannis 2017). These technologies have an electronic basis (Moffatt et al. 2017), and have considerable potential for enhancing the functional communication needs of individuals who require AAC (Light et al. 2019). Along with the increasing popularity of AAC apps, there are also some circumstances in which they do not provide sufficient communication and language-development (Light & Drager 2007). The design of AAC apps is one of the important factors on the success of it (Light, McNaughton et al. 2019). Many studies (Boster & McCarthy 2018; Light & Drager 2002; Light et al. 2007; O'Neill & Wilkinson 2019) have recognized the importance of design issues (e.g., visual scene displays and navigation-bar) of AAC apps. However, because of the divergent needs of the users relying on these apps the research on the subject needs further and more in-depth research especially from an instructional system design (ISD) perspective. This perspective provides a systematic, learner-centered, and goal-oriented view to solve real-world problems in an effective and efficient way (Gustafson & Branch 2002). It begins with the in-depth analysis of the problem situation and proceeds through the evaluation of the possible sets of solutions. Instructional designers, instructors, and subject-matter experts fulfill a group of instructional tasks throughout the process (Kemp et al. 1998). In the end, an instructional method and/or a material is proposed (Heinich et al. 1999) by considering the core elements of instructional design; including objectives, learners, methods, and evaluation (Kemp et al. 1998).

From an instructional design point of view, a confusing design may increase the extraneous cognitive load of the users (Mayer & Moreno 2010). The cognitive load theory implies that effective design of any system reduces the element interactivity and allows users for allocating more working memory resources to the learning task (Sweller et al. 2019). In cases having high intrinsic cognitive load such as understanding the logic behind the communication, the way how the material (i.e., AAC app) is designed and presented has a critical role in reducing the total cognitive load, thereby the success of the intervention.

The design issues of AAC apps can be put into a more comprehensive perspective, which will refer as the "design specifications" for this study. The term "design specifications" refers to both functional and non-functional requirements of systems (Chung & do Prado Leite 2009). What is distinctive about the definition is the emphasis on the non-functional requirements, which addresses several qualities behind the functions attributed to the system, such as usability and mobility.

Researchers in the field have asked the questions concerning the potential effect of AAC systems on communication skills and reported significant positive benefits for individuals with ASD in expressive language (Ganz et al. 2017; Genc-Tosun & Kurt 2017), receptive language (Ganz et al. 2015) and speech production (Wojciechowski & Al-Musawi 2017). Only a few studies have touched upon the design specifications of AAC apps based on the characteristics of individuals with ASD and demands of practitioners (Boster & McCarthy 2018). There is also little written about the practical solutions towards theoretical design-related issues of AAC systems. Therefore, it is necessary to ask questions regarding how to optimally design AAC apps for the needs of practitioners, families, and individuals with ASD. The purpose of this study is to investigate the design specifications of mobile technology-based AAC apps for communication needs of individuals with ASD. The following research question guided the study: What are the design specifications of AAC apps designed for

individuals with ASD, based on subject-matter expert opinions? The answer of the question will give insights into understanding the design heuristics of AAC apps.

Method

Research Design

Design based research (DBR) framework was employed to gain insight into design specifications of mobile technology-based AAC apps. The DBR framework includes a group of research methods (Wang & Hannafin 2005) to systematically investigate the design, development, and evaluation of instructional programs, processes and products (Seels & Richey 1994). It focuses on complex real-life problems that are of interest to practitioners and researchers in education (Reeves et al. 2004). Design and development of possible solutions are accompanied to in-depth analysis of the problem situations, which is also called prototyping procedure. Each prototype is evaluated by experts till to reach ultimate version of the solution.

The DBR framework was chosen in this study because of two reasons. First, the syntax of Turkish language is different than that of English language. In this regard, adapting a global app to Turkish generally cause some consistency problems. For example, the first-person singular in the sentence is not pronounced in daily life and the verb is written at the end of the sentence. Although, it is possible to compensate these syntax rules by using speech production features of mobile devices, the synchronization of speech output and the visual-scene design of the app requires a new screen design for Turkish context. Accordingly, the DBR may provide a favorable framework to design and develop effective AAC apps based on the characteristics and cultural needs of individuals with ASD in Turkey. Second, the number of AAC apps in Turkey is very limited. Design of new apps may increase the awareness of society towards AAC apps in Turkey. The seriousness of effective AAC design for successful AAC intervention underlines the need for more concerted research effort to develop more user-centered AAC technologies (Light & McNaughton 2013). It seems reasonable to suggest focusing on research and development of AAC apps by considering the needs and skills of individuals with ASD and their parents, as well as the technological affordances (Light, McNaughton et al. 2019). In this sense, DBR framework may help to develop acceptable AAC apps with design guidelines from an ISD perspective.

Participants

Special education teachers (n = 5), subject matter expert (n = 1) and faculty of special education (n = 8) took part in different stages of data collection as summarized in Table 1. Criterion based purposive sampling technique was employed as suggested by Patton (1990) to select participants.

All participants had bachelor-degree in special education. Their work experience ranged from 3 to 20 years (M=7.07) in the field., The teachers had at least one child diagnosed with ASD in their classrooms at the time when the study was conducted. The teacher who participated at the first expert-review stage of the study was also instructing a graduate course on design of instructional materials for individuals with disabilities in a public university. The faculty had also experience in AAC related work. The nature of the study was explained to each

participant and a consent form was signed before collecting the data.

Table 1. Participant Characteristics

Participant	Stage	Gender	Experience
Special education teachers	Focus group study (Analysis)	F	7
		F	6
		F	3
		F	3
		M	5
Expert	Expert review I (Formative evaluation)	M	10
Academicians	Expert review II (Summative evaluation)	F	3
		F	7
		F	10
		M	5
		M	7
		M	20
		M	8
		M	5

Procedure

The development process of the AAC app was accelerated after the literature review as suggested by Tripp and Bichelmeyer (1990). The design process of the study in the DBR framework was illustrated in Figure 1. Accordingly, after developing the first prototype of the AAC app, EBA, which stands for "engelleri birlikte aşalım", a common expression in Turkish that means "let's overcome the obstacles together", a focus group study was conducted with special education teachers in a seminar room. Tape recording was made during the focus group study. The aim of the focus group was to provide more realistic design and to understand how the theoretical aspect of the problem is associated with practical solutions in the field.

An expert review study was designed to make a formative evaluation on the app. The EBA app was first introduced to an expert in designing instructional materials for individuals with special needs, and then the expert used the app for about two hours in a day without getting any help. An in-depth interview was conducted with this expert and based on the feedbacks gathered from the expert review, the EBA app was revised and the ultimate prototype was released.

In order to make the summative evaluation of the EBA and to propose ultimate design specifications for AAC apps, a second expert review was designed. An introductory video of the EBA was prepared and shared with faculty in special education. They first watched the video and then filled an online survey. Consequently, final

design specifications with practical solutions were proposed for AAC apps based on the analysis results of the survey.

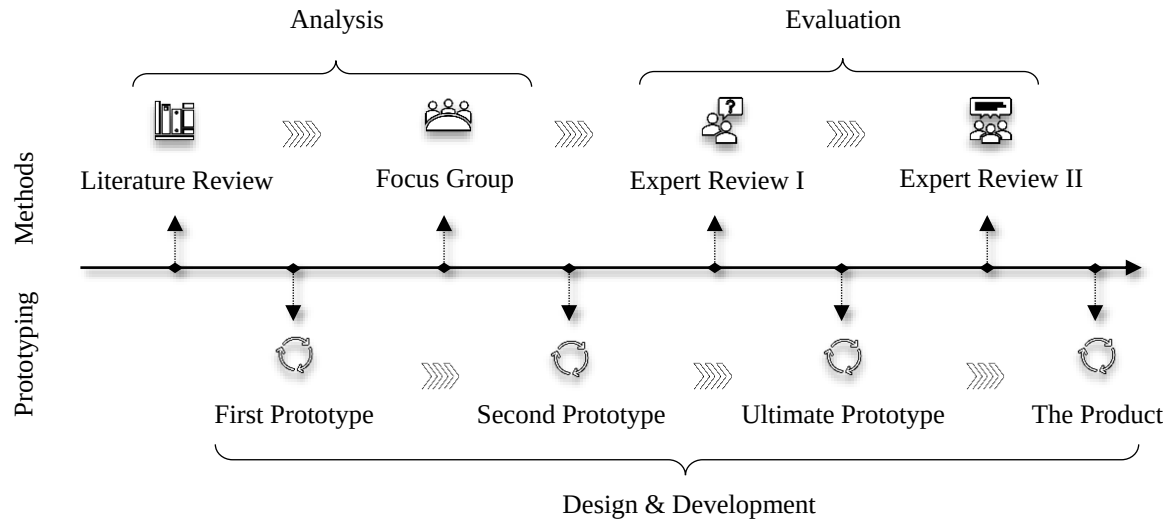

Figure 1. The Design-based Research Framework in the Current Study

Instruments

A focus group interview protocol, a semi-structural interview protocol, and an online survey was used to collect data. Instruments were prepared by researchers and evaluated by two experts with PhD in special education and instructional technology departments. Each instrument was put into its final form after taking feedbacks from subject-matter experts.

The focus group interview protocol consisted of 23 questions comprising three dimensions, including the characteristics of individuals with ASD, use of mobile technologies for communication needs of individuals with ASD, and the design issues of AAC apps. The interview protocol included 18 questions addressing the usability and suitability of the second prototype of the EBA app. Finally, the online survey was developed in Google forms and included 7 Likert-type and 13 open-ended questions. The Likert questions were scored from 1 to 5; where 1 was totally disagree, and 5 was totally agree.

Material

The first prototype, an AAC app named EBA, was designed to be used by individuals with ASD to initiate communication. It was redesigned in different remediation cycles of DBR process based on the suggestions and opinions of the subject-matter experts. The first prototype of the EBA requires a user-account and provides a customizable user platform (Figure 2). It demands several personal information (e.g., name, profile picture etc.) about the user. Once the user log in the system, the app recognizes user information for the following logins.

The EBA provides three categories (i.e., home, school, and free-time) to which users may add contextually related communication objects. Users may also add new categories and customize them if required. Once they touch a

category icon on the screen, two options are provided; learning objects and make sentence. These options can be used for simple and multistep requesting in the functional communication interventions. The number of communication objects may increase depending on the user preferences. To add or update an object, user need to use setting page of the app which can be accessed at the right-top of each screen. The app can be operated in accordance with the "just-in-time" strategy by capturing the image of objects and using digitized or synthetic sounds in a contextually related setting. When the user touches any object, its image is represented on the top of the page with a corresponding digitized speech.

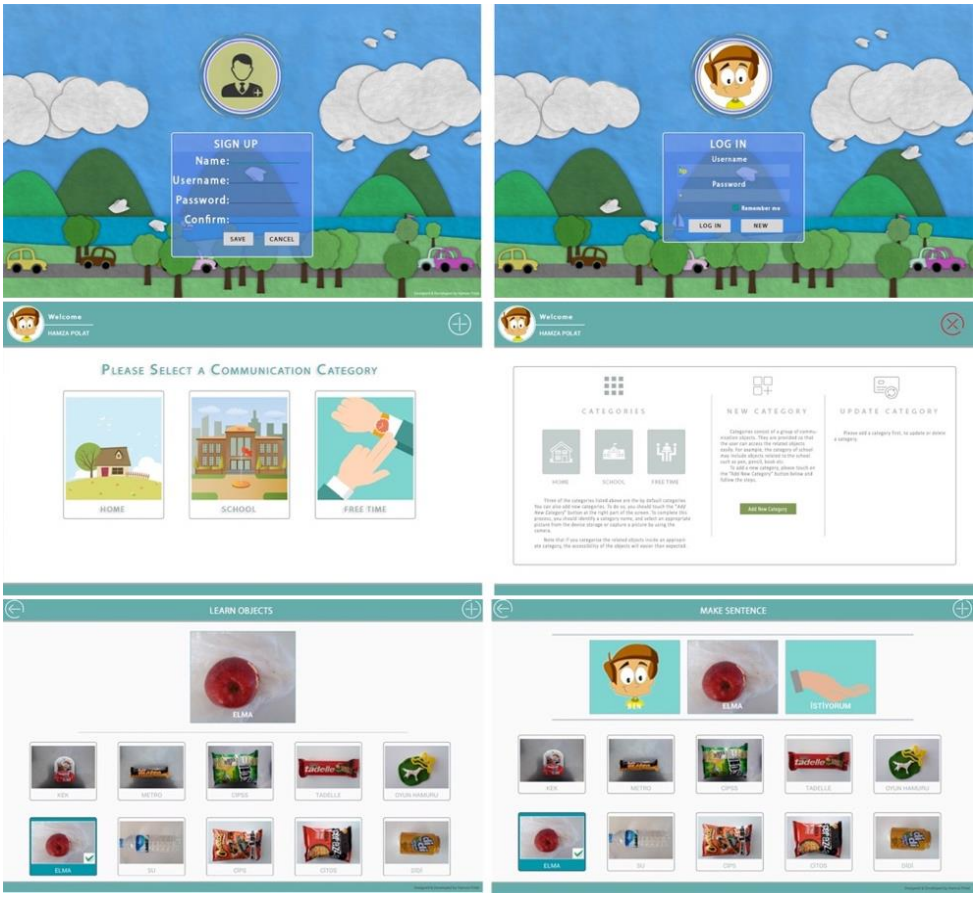

Figure 2. Example of EBA User Interface. Users need to: (a) log in the system; (b) select or create a new communication category; and (c) experience with the communication objects in a simple or functional environment.

Data Analysis

Both qualitative and quantitative data collection methods were employed in the present study. The qualitative data was obtained from analysis, formative and summative evaluation phases of the study. To analyze the qualitative data, data analysis procedure prescribed by Corbin and Strauss (1990) was used. The qualitative data was transcribed manually in each phase of the study. A researcher began the analysis by open coding procedure where categories were derived. The connection between categories and subcategories was established in axial coding. Categories were selected and related to form themes during the selective coding. In the meantime, design specifications of AAC apps were derived from categories and themes.

'Peer debriefing' and 'triangulation of observation' strategies were employed to enhance the trustworthiness of the qualitative data analysis (Creswell 1998). First, a peer debriefing process was conducted with an instructional technologist who is knowledgeable about and has experience in qualitative inquiry. The themes and design specifications generated during the analysis phase were checked to reduce the effects of bias and reactivity, which was done in each phase of the study.

After peer debriefing process, the initial codes, categories, and themes were shared with two reviewers with PhD: an instructional technologist and a subject-matter expert. They reviewed and checked the initial codes, and filled a checklist whether the codes, categories and themes were labeled appropriate or not. A reasonable consensus was reached on the themes and categories.

Second, a triangulation of observation process was initiated to ensure the inter-observer reliability. The codes, themes and categories were shared with two experts with PhD in the field to check the appropriates of themes and design specifications. A consistency threshold of 90% was employed for themes and design specifications (Miles & Huberman 1994). The consistency level was 89.3% for focus group analysis, 92.7% for first expert review analysis, and 89.6% for qualitative part of the second expert review analysis.

Results

Findings from the First Remediation Cycle

Focus Group Analysis Results

According to teachers, children with ASD can be able to use mobile devices to meet their needs without getting any support. Particularly, they are very interested in mobile games and can play them without someone's help. One of the teachers stated that:

> We have a student with ASD who has lack of receptive language... His mother came to school with her mobile phone recently. He took her phone, connected to the Internet and opened an online game. Then, he played the game in a way that I would not be able to do (Teacher 4).

Teachers believed that drawing attention of children with ASD is crucial to ensure the success of any technology integration in children's education. Teachers were optimistic about the use of mobile technologies for educational purposes. One of the teachers expressed that:

> Last month, one of our friends brought her tablet to school. We downloaded some games for matching activities in classroom. We studied these games in the class. Then, the learning activities became more enjoyable for the students, just like a game not a lecture, and they participated the activities more entertainingly and willingly (Teacher 1).

Teachers believed that children with ASD can be motivated to do learning activities with the help of mobile technologies. They were in the opinion that visuals, colors and sounds should be integrated into mobile apps

effectively to capture their attention. In particular, the apps should include relevant visuals since the target group have impairments in literacy. For example, one of the teachers stated that "because they [children with ASD] do not know reading and writing, the app should be supported with visuals as much as possible" (Teacher 2).

According to teachers, without considering how the design elements of AAC apps (e.g., visuals, colors, etc.) offered, they do not make sense for children with ASD. One of the strategies was to increase the number of visuals on the screen gradually. All of the teachers had the same opinion about this issue. A teacher stated that "the number of pictures can be increased gradually since the severity level of the ASD is different for each child. Two pictures, for example, can be used at first. For the next level, another procedure can be used" (Teacher 1). When children use these visuals for communication, the system should provide immediate feedback for their actions. As one of the teachers stated "it is possible that a child with ASD becomes distracted easily and may interests in different tasks when s/he does not reach a goal" (Teacher 3). The other issue is the use of colors depending on the individual differences. Although, it was suggested that background of the screen should be bright with colorful objects, some of them concerned about several unproper colors. For instance, a teacher stressed that:

> Some of students [with ASD] do not like several colors. For example, I witness the color of yellow. Some of them are afraid of yellow or do not want to see it. Therefore, the background of the screen should not be the colors disturbing the students (Teacher 5).

The analysis results showed that children with ASD are more sensitive to the voice of their family members. Therefore, teachers suggested that AAC apps should be programmed with not only synthetic but also digitized real voice.

Design Specifications after Focus Group Analysis Results

Initial design specifications were generated after the focus group analysis results as follows: (a) Users can be able to personalize all the features of the app depending on their needs, including colors, visuals, themes, and sounds; (b) the design of each screen should be as clear as possible, should not include unnecessary objects that may distract user attention; (c) the number of visuals referring communication objects should be increased on the screen gradually; (d) practitioners can be able to program the app with digitized voices to generate more natural speech output; (f) the AAC app should generate immediate feedback (speech or visual) to each context-related actions of users.

Findings from the Second Remediation Cycle

The second prototype of the app was released based on the initial design specifications. Two main improvements were made on the second prototype. First, a log-tracking system was added to keep the log files of the users. Second, a control panel was added to the categories page for practitioners. This panel was designed to increase the autonomy on the system. Practitioners can use this panel; (i) to change the template of the app and personalize the colors, (ii) to update all of the voice records, and (iii) to track the user logs.

Formative Evaluation of EBA, First Expert Review Analysis Results

An expert review was conducted to reveal more design issues of the revised version of the EBA. The expert was concerned about the of obsessive behaviors commonly seen in ASD. Accordingly, children with ASD need to be restrained while using any mobile device individually. He stated that:

> Particularly, children with ASD should not be exposed to screen-based media very much. I mean, if they spent too much time with them, they can get obsessed with such media… When you try to remove the media, this time, certain undesired behaviors occur, such as resisted behaviors, deliberate self-harm, and crying, which might continue until getting the desired object.

Practitioners, teachers, or families generally may take part in AAC interventions. To make this procedure more effective, these people should be familiar with the AAC system before the use. In this regard, the expert reminded the necessity of having user manuals of proposed AAC app. He touched on this issue by saying:

> Actually, we need someone who can teach the use of this app or something from which we can learn the use of this… I mean, we need a user-manual; what the ultimate goal is, and what kind of behaviors we are expecting from the children while they are using it.

The expert also evaluated the navigation system of EBA. He made some suggestions to increase the ease of use of the system. One of these suggestions was the font size of the informative texts. The expert warned that the size and the colors of the fonts could be changed depending on user preferences. Finally, he expressed his satisfaction with the visual representation of desired objects on a board, the speech-generating feature of the app, and portability and affordability of the app.

Design Specifications generated from the First Expert Review Analysis Results

The expert has reviewed several usability issues during the second remediation cycle. Based on the expert's concerns, three more design specifications have been proposed as follows: (a) the app should include practical solutions for possible obsessive behaviors, (b) AAC apps should include help documentation to guide practitioners for accurate AAC implementation, and (c) the characteristics of informative texts should be customized by users.

Findings from the Final Remediation Cycle

The third prototype of the EBA was released based on design specifications. By keeping the core features of the previous versions of EBA, two main improvements were made on this prototype. First, a parent control service was integrated into the platform to prevent children from any possible obsessive behavior regarding to the use of EBA app. This feature helps practitioners or families to schedule the training time of the AAC intervention with EBA. When the users get out of the schedule, the app locks all the features till to rearrange the schedule. This feature can be enabled or disabled from the user control panel by practitioners. Second, a user manual of the EBA

was added to the system. It included help documents of the EBA as well as brief information about the AAC interventions for individuals with ASD. Practitioners can access these documents by visiting the login page.

Summative Evaluation of EBA, Second Expert Review Analysis Results

The second expert review was conducted with faculty to get their opinions that might add value to the app. They asked for several new features that should be integrated into the EBA platform, which are presented in Table 2. They suggested several issues addressing social communication and interaction (Expert 2), and physical and emotional actions (Experts 8 and 4), including more complex sentence formats (Expert 6), adding an item pool to the system (Experts 3 and 8), making the help documents more functional such as providing an introductory video of the EBA (Expert 3) and giving brief information about the ASD (Expert 5).

Table 2. Participants satisfaction level with EBA

Category	Responses
Need refinements	To make the app more usable and understandable, *voice records should be more natural*. The time interval between words may be reduced (Expert 6). The *icons* of the communication objects should be provided in the middle of the screen *with bigger sizes* (Expert 1). *Alternative* ways should be offered at the *sentence structure* sections. For instance, while requesting a pen, it is not natural to say "I." I mean, we prefer to use "Kalem istiyorum" [means, I want a pen, without pronouncing the subject of the sentence] rather than "Ben kalem istiyorum" [means, I want a pen] in daily life (Expert 5). Instead of naming categories, an expression like "What would you like?" or "Select a place" can be used. Furthermore, while selecting a page, *a vocal notification* might be provided as a target language prompt for the children with illiterate (Expert 8).
Requested features	A new section should be added to EBA for expressing *social communication* skill such as 'Thank you' and 'Excuse me' (Expert 2). The system may support *new expressions for physical or emotional actions* (e.g., 'I have a stomachache', or 'I am angry') (Expert 8). *Different user profiles* can be identified at the app *for different children*. More complex sentence structures can be added to the system for the ones who start to speak (Expert 6). *Pictures addressing* the "*actions*" might be provided. For example, "I want to run." Furthermore, the app is including a requesting sentence form. The type of the verb and subject can be varied. This can make it difficult to use. But I still believe that this diversification can be made by considering the ease of use. Maybe the app can include different levels (Expert 4). To make the app *more functional*, there should be *default pictures* for practitioners. Individuals with communication impairments may not create their own categories (Expert 8).

Design Specifications generated from Second Expert Review Analysis Results

Four design specifications for high-tech AAC apps have been revealed based on the summative evaluation results of the EBA: (a) object icons on the screen can be resized and repositioned by the users; (b) sounds should be as natural as possible by decreasing the gap between sentence components while the device is generating speech; (c) the system should support different sentence formats by which users can express not only their needs but also their feelings in different contexts; (d) the system should include by default communication objects with corresponding visuals and digitized sounds.

The Final Version of the EBA

The final version of the EBA was released after the second expert review results. The following refinements were made on the last version of the EBA: (a) a new feature was added to the system to resize and reposition the communication objects; (b) the quality of the sounds was improved by reducing the gap between the sentence components while the device generating voice output. Sentences in Turkish starts with the subject. If the subject is first-person singular, then the subject is not pronounced in daily language. In this regard, (c) the vocalization of the subjects was made optional for users. (d) Help documents were supported with video materials about the use of EBA with picture exchange communication system (PECS) protocols. (e) An image pool consisting of PECS cards was also integrated into the platform.

Discussion

The purpose of this study is to figure out the design specifications, which are the design issues that address the appearance, functionality, flexibility, and usability of AAC apps. Design specifications were generated from the considerations of both special-education teachers and faculty in special education field. In the meanwhile, these specifications were implemented on an AAC app named EBA.

More Personalized AAC Apps

This study suggests multiple options for colors and theme preferences on AAC apps. Based on the special needs of individuals with ASD, the system should allow for customizations of colors, visuals, sounds, themes, and screen-display. AAC apps should provide a flexible basis for communication acts of individuals with ASD to capture and sustain users' attention (Light & Drager 2002), and plays a remarkable role in performance (Light, Wilkinson et al. 2019). Designers, therefore, need to pay more attention to the individual differences while designing AAC systems (Light & Drager 2002; Light et al. 2007). One way to meet the individual differences in any context is to support the just-in-time programming strategy (Caron et al. 2017; Drager et al. 2019; Holyfield et al. 2018). This strategy not only help users to initiate communication with the contextually-related desired objects but also ensures the customization of color (Light et al. 2004), themes (Light et al. 2004, 2007) speech outputs (Light et al. 2004), size and positions of visuals (Costigan et al. 2012), and some other design elements of AAC apps.

Visual Displays

While interacting with the user-interface the users may face two types of visual displays: grid displays and visual scene displays (VSDs). The current literature suggests that VSDs should support the use of personalized photos in which people familiar with the users engage in relevant activities and semantic navigation bars with thumbnail VSDs (Light, Wilkinson et al. 2019). Research also suggests that grid displays that include strategies of clustering symbols and providing spatial cues make visual searching and selection process easier for individuals with developmental disabilities (Light, Wilkinson et al. 2019). However, some of the AAC apps may also combine the characteristics of both grid-displays and VSDs (Light, Wilkinson et al. 2019). In the present study, while designing the AAC app, namely EBA, both of the elements of VSDs (e.g., personalized photo VSDs with thumbnails) and grid displays (e.g., spatial cues and clustering) were employed. From this point of view, although, the present study does not give insights into the selection of visual displays in AAC apps, it proposes that the size and the positions of the visuals should be arranged to make them more functional.

Simple User-interface without Distracting Stimulus

Current study offers several suggestions to make the visual display of AAC apps more suitable, which are: (a) the screen should be large enough to suit the physical development of the individuals; (b) the app should run on full-screen mode; (c) the background of the app should be bright and simple; and (d) irrelevant media elements should be removed from the screen. Individuals generally access to AAC apps through a unique audio-visual display on which the relevant items are presented, including icons, photos, and navigation-bar. Distracting stimulus on visual displays of AAC apps may draw users' attention to the irrelevant parts of the screen, which is not a desired situation during the AAC interventions. An AAC app should have a simple display design to make the interventions more engaging and effective. Additionally, a simple design makes the AAC app more usable by decreasing the operational demands of the app (Caron et al. 2017; Caron et al. 2016), and reduce the extraneous cognitive load while interacting with the app (Sweller et al. 2019). When, the element interactivity is decreased by ensuring low extraneous cognitive load, individuals with ASD can allocate more cognitive resources to construct relevant schemas related to the learning task during the AAC interventions.

Hierarchical Representation of Visuals on Display

The present study revealed that the visuals addressing communication acts should be presented gradually on the navigation bar, which implies an instructional strategy, a way of managing intrinsic cognitive load during the AAC interventions. An instructional strategy is required to teach the use of AAC systems during the interventions. It can be confidently asserted that individuals with ASD need appropriate instruction to learn operational, strategic, social, and linguistic skills so that they develop or enhance their communication skills with the support of AAC apps (Light, McNaughton et al. 2019). Additionally, the success of the intervention is also closely related how the AAC system is taught to individuals with ASD. The current study suggests the use of PECS protocols (Bondy & Frost 1994) with several modifications, as implemented by Genc-Tosun and Kurt (2017) in an AAC intervention. Accordingly, the PECS intervention begins the functional communication with a simple picture-

card, and the numbers of the cards are increased on the PECS book gradually. Likewise, we suggest that AAC apps should allow for hierarchical representation of visuals addressing communication objects or activities on the navigation bar. Presenting these visuals in a simple-to-complex sequence on the screen optimize the intrinsic cognitive load (Sweller et al. 2019). In other words, the element interactivity during the AAC intervention is reduced initially, and then the progress of the full-element interactivity is promoted. This strategy, greatly simplify the teaching procedure of the AAC apps and is more suitable for individuals with different severity levels.

More Responsive AAC Apps

Individuals with ASD should be able to perceive the response of the app as soon as they touch the screen. They can initiate or sustain functional communication by touching visuals on the navigation bar of AAC apps. One of the worth-stressing points, here, is that the system should provide feedback to each action of individuals within a reasonable time, which was also emphasized by Light et al. (2004). This study suggests different strategies to ensure this issue. First, once the user touches the visuals on display, a vibration effect can be produced by the device, which may help users to understand whether the deserved action is in progress. Second, the representation of desired objects or activities should be illustrated on the visual display of screen in an appropriate size. Meanwhile, the system should generate a speech output in a way that can be understood by the user.

Help and Documentation

Help documentations might be in different forms, including tooltips, videos and online helps. The current study also suggests to use of informative texts while programming the app to keep users informed about the procedure. Additionally, the documentation should not only focus on the programming procedure of the app, but also the AAC interventions. By means of that families having less opportunity to access special education services can benefit from AAC apps.

All technology-based systems need help documentation that focus on user's tasks (Nielsen 1993). Similarly, AAC apps require particular operational demands that may not be achieved without documentation. While programming and using the app, parents and practitioners need to follow certain steps. A typical user, during this process, may need help-documentation so that they become more experienced with the system (Nielsen 1993) and may search for appropriate solutions to the problems they faced while interacting with the app. In this regard, help-documentations is one of the frequently recommended options to meet such needs.

Output System

Individuals required AAC systems generally obtain language inputs through spoken language, but the type of language output may change in AAC interventions (Light 1997). Both visuals and sounds would be a language output of AAC apps (Light & Drager 2007). While selecting the output system, the following factors should be considered: (a) intangibility of the speech output and (b) effectiveness of AAC intervention.

The present study suggests the use of both visuals and sounds concurrently as an output system; however, the type of the output might be changed based on the individual and cultural differences of the users. The system should also offer an object pool including visuals with corresponding sounds to make the AAC apps more efficient during the programming stage. The type of the speech, whether it is digitized or synthetic, may affect intangibility of speech output. Although there is no clear evidence about the effectiveness of speech output on intangibility, digitized speech is thought more preferable than synthetic speech since it is close to natural human voice (Schlosser & Koul 2015). Additionally, to get better results in learning performance and thereby increase the success of the AAC interventions (Mayer 2001), AAC apps should support visual displays with speech output, as emphasized by many researchers (Drager et al. 2006; Mirenda & Beukelman 1987).

Parental-control Service

Individuals with ASD generally adhere to certain routines strictly in daily life, which may cause selectivity, and thereby the development of obsessive behaviors (Hyman & Levy 2013), which was also emphasized in the analysis phase of the present study. To prevent individuals from obsessive behaviors related to the overuse of the AAC apps, a practical solution might be integrated into the system. In this sense, the results of the interviews suggest parent-control service to AAC apps to keep individuals from abnormal behaviors. This control allows practitioners to limit the use of device for a certain time of period.

Limitations and Future Directions

Design specifications of AAC apps are an important concern to which researchers need to pay more attention. The demand is to find more effective systems that are easy to use, affordable, and appealing for individuals (Meder & Wegner 2015), families, and practitioners (Light & Drager 2002). The present study focused on the general design issues of these apps based on the opinions of teachers and faculty. With respect to the families' concerns, however, some crucial questions need further investigation in future studies.

The design of AAC apps may undoubtedly vary according to the needs, skills, and interests of individuals with ASD (Light & Drager 2002). However, many questions (e.g., appeal of the system, strategies to reduce learning demands of navigation systems, effective layout design and organization methods) still need further investigation to reveal design specifications in different contexts. Additionally, there is also a need for empirical evidence about the effectiveness of AAC apps developed with proposed design specifications in practice.

Ideal AAC apps should be usable by both children and practitioners. Cognitive demands of a usable app are fewer than that of other apps (Light & Drager 2007), which facilitates the learning process of application, and enhance the performance, satisfaction and workload (Caron et al. 2017). To minimize the operational demands of AAC apps and facilitate the communication, therefore, there needs usability guidelines for individuals with ASD (Light, Wilkinson et al. 2019). In this regard, Nielsen (1994) proposed several heuristics for general user-interface. However, there is also need for research and development to test these heuristics on AAC apps, or to reveal new heuristics appropriate to individuals required AAC.

Conclusion

The purpose of this study was to examine the design specifications of AAC apps for individuals with ASD. In line with this purpose, a mobile AAC app was developed based on the considerations of both special-education teachers and faculty. During the designing process of the app, several design specifications were proposed to make the AAC apps more appealing, useful, and engaging for the target group.

The most remarkable result was that AAC systems should provide a flexible framework by which practitioners can personalize the system according to the special needs of users. Because of the individual differences, for example, colors, themes, sounds, visuals, the size and the positions of the visuals can be specialized by the users. Given the characteristics of individuals with ASD, the display of the AAC app should be designed in a way that does not include distracting stimulus. The screen size of the device should be appropriate to the target group to take their attention and also motivate for using. The visuals on the navigation bar should be designed in a way that can optimize the intrinsic cognitive load. The system should allow for just-in-time programming strategy by inserting and updating relevant visuals in the related contexts. Additionally, the system should be usable and the operational demands of the system should be low to reduce the extraneous cognitive load and to facilitate the essential processing while the user is interacting with the interface of the application. Furthermore, AAC apps also should meet the needs of practitioner and families; such as help documentations and parent control services.

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