Human Factors in the Design of Arabic-Language Interfaces in Assistive Technologies for Learning Difficulties

Sahar Alkhashrami[1], Huda Alghamdi[2], and Areej Al-Wabil[3]

[1] Department of Special Education, College of Education, King Saud University, Saudi Arabia
salkhashrami@ksu.edu.sa
[2] Disability Service Center, King Saud University, Riyadh, Saudi Arabia
hudalghamdi@ksu.edu.sa
[3] Software Engineering Department, College of Computer and Information Sciences, Software and Knowledge Engineering Research Group, King Saud University, Saudi Arabia
aalwabil@ksu.edu.sa

Abstract. This paper reports on insights gained from collaborations between multi-disciplinary research teams and practitioners in a Disability Service Center in King Saud University (KSU) in Saudi Arabia. Projects were conducted in the context of designing, developing and evaluating different assistive technologies in the university's Software and Knowledge Engineering Research Group. In these projects, methodological considerations have been reported for effectively involving domain specialists in research and development projects for assistive technologies. Subject Matter Experts (SMEs) are often involved in the technology design cycles of these projects in various roles (e.g. design partners, design informants, testers). This paper highlights the human factors relevant for the design and evaluation of interactive systems for SpLDs that were synthesized from these collaborative contexts. We also shed light on issues to consider in the design partnerships between researchers and practitioners for requirements engineering and user acceptance testing phases of system development. Implications for the design and development of systems for SpLDs in other languages and cultural contexts are discussed.

Keywords: SpLD, Learning Difficulty, Dyslexia, Brain-Computer Interaction, BCI, Usability, User Experience, Disability, Attention Deficit Disorder, ADHD, Augmentative and Alternative Communication, AAC, Arabic Interfaces.

1 Introduction

Despite growing awareness of usability and accessibility issues for designing interactive systems for users with Specific Learning Difficulties (SpLDs), designers still face challenges when creating such systems and evaluating the users' experience (UX) with target user populations. One major stumbling block is a lack of understanding about how to effectively gain insights into the users' needs in the contexts-of-use of systems designed for screening, computerized assessment, cognitive training, and

M. Kurosu (Ed.): Human-Computer Interaction, Part II, HCII 2014, LNCS 8511, pp. 362–369, 2014.

learning. In recent years, different methodological considerations have been reported for involving domain experts in research and development projects of assistive technologies in various contexts [1], [5], [10]. Subject Matter Experts (SMEs) are often involved in the technology design cycles in various roles ranging from the role of design partners such as in the dyslexia screening programs described in [2] and the augmentative and alternative communication (AAC) system described in [7]; design informants such as in [3-5], [8-10] and [17]; and participants in usability evaluations and User Acceptance Testing (UAT) as reported in the systems described in [6] and [14].

Several multi-disciplinary projects were conducted in the context of designing, developing and evaluating assistive technologies for people with disabilities in collaborations between a Disability Service Center in King Saud University (KSU) and a multidisciplinary research group, the Software and Knowledge Engineering Research Group [20]. This paper highlights the human factors relevant for the design and evaluation of interactive systems for SpLDs that were synthesized from these collaborative contexts. Emphasis in the joint activities between the disability service center and the research teams is often on interface design considerations for our target user populations, interaction modalities for input and output that match the needs of users with SpLDs, cultural and language considerations for designing Arabic interfaces.

This paper is organized as follows: Section 2 describes the human factors that are relevant to the context of designing interactive systems for users with Specific Learning Difficulties. Section 3 describes the methodological considerations for involving subject matter experts, practitioners, and users in the design cycles of such interactive systems. We also shed light on issues to consider in the design partnership between researchers and practitioners for requirements' engineering and UAT phases of system development. Section 4 concludes with synthesis of our insights from these projects and lines of future work in multidisciplinary partnerships between researchers and practitioners involved in the research, design and development of assistive technologies.

2 Human Factors in Systems Designed for SpLDs

Individuals with Specific Learning Difficulties (SpLDs) can demonstrate a wide range of cognitive and behavioral abilities on a spectrum of difficulty levels. Moreover, there can be considerable variability within different cognitive capabilities of individuals with a specific difficulty. For example, dyslexics are a heterogeneous group and no two dyslexics are alike; a child with dyslexia can be both good at sequencing and weak in phonological processing of written language. Intelligent interactive systems offer a viable mechanism to provide a personalized user experience (UX) and adaptive modes of interaction to support the multitude of individual needs in people with SpLDs. SpLDs offer some specific design challenges such as the need for configurable controls to account for individual differences in target users, interaction modalities, and types of multimedia feedback that match users' abilities.

The development of interactive systems for supporting individuals with SpLDs has progressed along with the success of frameworks for integrating SMEs, practitioners, and users in the User Centered Design Cycles (UCD) of these systems [1], [9-10], [16-17], [19]. User modeling is essential in requirements engineering phases of assistive technologies to understand the perceptual, emotional, physical, and cognitive capabilities of users [21]. Modeling of users is important to identify functional and non-functional requirements, estimate behavior of users, and simulate scenarios of usage in testing phases. Insights from SMEs and representative samples of real users aid in developing accurate user models for specific target user populations.

Software designers and system developers can refer to user models in comparing design alternatives, input modalities, navigation structures, and multimedia presentations of content. As noted by Simpson in [21], user modeling is not intended to eliminate the need to conduct usability evaluations with real users, but it has been shown to effectively reduce the cost and complexity of the design process and accelerate the development and deployment process. Projects described in [8-13] have utilized user modeling for accelerating the software development process. Furthermore, personas have been used in [5] to model users in early phases of the design process for an auditory discrimination software program and these personas were used later in the project (i.e. in testing phases) to guide the UAT sessions with real users who had SpLDs in local school contexts. User models also guided the design and development of projects described in [2-4], [6], and [8] and deployed versions of these systems were tested with real users in collaboration with KSU's DSC. Moreover, heuristic evaluations were conducted with practitioners in the DSC center in iterative cycles of development for the systems described in [2] and [3] with low-fidelity and high-fidelity prototypes of assistive technologies. Figure 1 shows screenshots of these systems that use gaze-based and brainwave interaction methods which need UAT sessions to examine the UX, usability and subjective satisfaction with these emerging technologies.

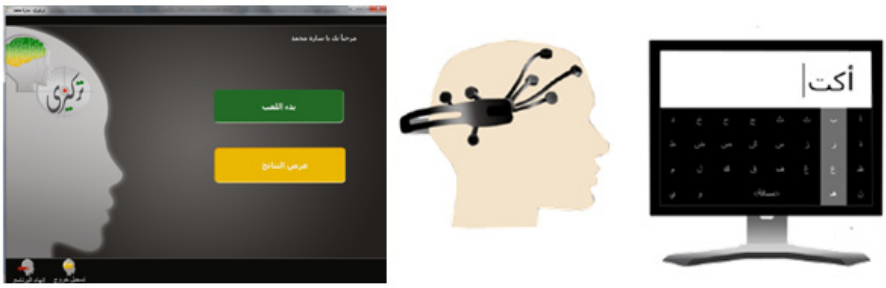

Fig. 1. Interaction modalities of gaze and brain-computer interfaces

A summary of human factors in systems designed with Arabic interfaces, that are characterized with bi-directional interfaces which have right to left text rendering and left-to-right numeric presentation, are listed in Table 1. Projects in which these features were examined in collaboration with SMEs, practitioners, and users are also listed. The human factors that were particularly relevant for these contexts emerged either by the system analysts and designers or were highlighted by the practitioners in heuristic review sessions and focus group meetings.

Table 1. Human Factors in Interactive Systems for People with SpLDs

Human Factor Design Issue	Systems in which issues were examined
Dynamics of pointing and selection	
Default cursor positions	[2], [3] bi-directional interfaces in Arabic
Touch-screen design considerations for children and elderly users	[7], [17], [19]
Psychomotor movements in gaze-based interactive systems	[2], [3], [8], [16]
Psychomotor movements in Brain-Computer Interfaces (BCI)	[4], [18]
Sensitivity in selection modalities	Touch [7] Dwell time in Gaze [2-3], [8] Brainwaves [4], [18]
Text entry design consideration	
Size and resolution of keys	[3-4], [7-8], [17], [19]
Interchangeable layouts of navigation	[9-10] familiarity with existing non-Arabic systems was considered
Prediction	Frequency of use for Arabic letters [4], [6]
Visual design of interfaces	
Cognitive abilities and individual differences	[3], [5], [8-9]
Personalization and gender-specific design	[7], [10], [15] cultural contexts of gender-segregated learning and personalized avatars in interfaces
Configurable Text	Readability of Arabic text in [5] ,[9]
Perception and Interaction	
Multimedia adaptation	Language considerations [9-10], cultural considerations [15-17]
Embedded Arabic speech engines	[7] [10] insights from practitioners on perceived spoken phrases in Arabic

Iterative design cycles have facilitated incorporating these design recommendations in line with the design approach described in [1] and [10]. Different usability protocols [e.g. 14 and 18] have been applied to assess the efficiency, effectiveness, and subjective satisfaction of users in their interaction with such systems.

3 Methodological Considerations in the Interaction Design Process for Assistive Technologies

The use of UCD, ISO 9241 [22], in the design of assistive technologies has been gaining popularity in a variety of systems' development scenarios [2-10]. However, the

involvement of practitioners, users, and domain experts in roles such as design-partners and design-informants may not be the optimal if their integration does not take into account the planned activities for different phases of systems' development [1], [10]. For example, in phases of requirements engineering, system analysts need to effectively elicit insights into the needs of target user populations from users and SMEs as described in UCD activities of [2-3] and [5]. Careful planning of UAT phases is needed in collaboration with practitioners and SMEs so that usability engineers can effectively assess the system with representative samples of real users in performance-based evaluations such as sessions described in [6-10] or in heuristic evaluations with SMEs as conducted in KSU's DSC for the projects described in [2] for dyslexia, [3] for attention deficit disorders, and [5] for auditory discrimination therapy.

It is also important to note that limited resources were available that document benchmarks and best practices of collaborations between disability service entities from one side, and assistive technology research and development (R&D) entities in academic and industry contexts from the other side of partnerships in our local context. To address this issue, documentation and reporting of the collaborative projects was conducted with in-depth analysis of the UCD methods and the type of contributions from members involved in both the disability service center and the SKERG research group [20].

Specific activities include briefing and debriefing sessions in which the research teams would conduct walkthrough of the system with members of the disability service center to ensure that sessions are designed to meet the UCD objectives of evaluating design concepts or functionality from different perspectives such as in the design of [2] and [4]. Cultural context was very important in early stages of design and development. For this reason, projects often involve a survey of existing technologies, gaps in addressing the requirements of the local user population, and a critique of the functionality for similar systems designed for non-Arabic-speaking users or designed for different cultural contexts. The survey would highlight design opportunities for adaptation and activities would elicit a critique of alternative design proposals from SMEs and users in brainstorming sessions or in task-based assessment sessions with a specific focus on strengths and weaknesses of users with SpLDs.

4 Conclusion

In this paper, we presented an overview of human factors and methodological considerations for the contexts of assistive technology designed for people with SpLDs. UCD cycles can only be effective if users and SMEs are involved in key phases of the software development cycles in which their contribution is directly related to the functionality being considered and/or examined for users with SpLDs. The level and mode of involvement (e.g. design partners, design informants, testers) also need to be considered in relation to the complexity of the system and constraints of the system development project.

Several successful collaborations, between the Disability Service Center of KSU and multidisciplinary teams in the SKERG research group [21], have demonstrated

different approaches in considering partnerships between teams in R&D and practitioner contexts. These collaborations were established with the aim of eliciting insights into the user needs and efficiently evaluating the systems from the perspective of practitioners, domain experts, and real users. Key issues to consider in the design and development of systems for SpLDs that can be generalized to other contexts can be categorized into two areas; namely, human factors and methodological considerations in partnerships between researchers and practitioners for requirements' engineering and user acceptance testing phases of system development. For identifying human factors in interactive systems for users with SpLDs, language and cultural contexts need to be considered in the visual design, presentation, and mode of interactions. For methodological considerations, the level and type of involvement of practitioners, SMEs, and users needs to be determined based on user needs and established within the constraints of the software development project and organizations involved in the context of use. Collaborations need to consider examining the contrast between what has been developed in the scope of assistive technologies for SpLDs in other contexts and existing systems; and aim to identify design opportunities for adaptation, further development, and re-engineering to meet the target user population's requirements.

Future lines of research are planned to examine effective frameworks for collaborations in academic contexts and industry-oriented systems' development for assistive technology.

Acknowledgement. The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding the work described for Brain-Computer Interface projects and AAC through the research group project number RGP-VPP-157**.** Special thanks for all the students, researchers, and assistants involved in these projects; Najwa Alghamdi, Arwa Al-Rubaian, Bayan Alarifi, Ghada Al-Ofisan, Nora Al-Romi, Amani Musrea, Aljawharah Al-Abdullatif, Hadeel Al-Negheimish, Latifah Al-Mofeez, Nuha Al-Khalifa, Lama Al-Andas, Ashwag Alshathri, Arwa Al-Edaily, Arwa Al-Issa, Itisam Hazzaa, May Al-Humaimeedi, Lujain Al-Tamimi, and Bushra Al-Kadhi, Sara Drine, Sara Alkoblan, Arwa Alamoudi, Rawan Al-Abdulrahman, Modhi Almuzainy, and KSU's DSC staff and students.

References

1. Al-Abdulkarim, L., Al-Wabil, A., Al-Yahya, M., Al-Humaimeedy, A., Al-Khudair, S.: Methodological Considerations for Involving SpLD Practitioners in the Design of Interactive Learning Systems. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) ICCHP 2010, Part II. LNCS, vol. 6180, pp. 1–4. Springer, Heidelberg (2010)
2. Al-Edaily, A., Al-Wabil, A., Al-Ohali, Y.: Dyslexia Explorer: A Screening System for Learning Difficulties in the Arabic Language Using Eye Tracking. In: Holzinger, A., Ziefle, M., Hitz, M., Debevc, M. (eds.) SouthCHI 2013. LNCS, vol. 7946, pp. 831–834. Springer, Heidelberg (2013)
3. Al-Shathri, A., Al-Wabil, A., Al-Ohali, Y.: Eye-Controlled Games for Behavioral Therapy of Attention Deficit Disorders. In: Stephanidis, C. (ed.) HCII 2013, Part I. CCIS, vol. 373, pp. 574–578. Springer, Heidelberg (2013)

4. Al-Abdullatif, A., Al-Negheimish, H., Al-Mofeez, L., Al-Khalifa, N., Al-Andas, L., Al-Wabil, A.: Mind-Controlled Augmentative and Alternative Communication for People with Severe Motor Disabilities. In: Proceedings of the 9th International Conference on Innovations in Information Technology, UAE. IEEE CPS (2013)
5. Al-Wabil, A., Drine, S., Alkoblan, S., Alamoudi, A., Al-Abdulrahman, R., Almuzainy, M.: The Use of Personas in the Design of an Arabic Auditory Training System for Children. In: Proceedings of the 13th International Conference on Computers Helping People with Special Needs (ICCHP 2012) in the Universal Learning Design (ULD) track, Linz, Austria (July 2012)
6. Al-Wabil, A., Al-Issa, A., Hazzaa, I., Al-Humaimeedi, M., Al-Tamimi, L., Al-Kadhi, B.: Optimizing Gaze Typing for People with Severe Motor Disabilities: The iWriter Arabic Interface. In: Proceedings 14th International ACM SIGACCESS Conf. on Computers and Accessibility (ASSETS 2012), pp. 261–262. ACM, New York (2012)
7. Al-Arifi, B., Al-Rubaian, A., Al-Ofisan, G., Al-Romi, N., Al-Wabil, A.: Towards an Arabic Language Augmentative and Alternative Communication Application for Autism. In: Marcus, A. (ed.) DUXU 2013, Part II. LNCS, vol. 8013, pp. 333–341. Springer, Heidelberg (2013)
8. Al-Wabil, A., Alomar, A., Alhadlaq, K., Alrubayain, M., Alzakari, N., Alhamid, O.: Interactive Therapy of ADHD with Gaze-Based Games. In: Proceedings of the 10th Pacific Conference of Computer Human Interaction (APCHI) in Matsua, Japan. ACM SIGCHI (2012), http://apchi2012.org/catalog_poster/
9. Al-Harbi, O., Al-Arfaj, N., Al-Hathlool, L., Al-Ghofaily, M., Madani, D., Al-Wabil, A.: The Design and Development of an Online Multimedia Language Assistant for Web Users with Dyslexia. In: Proceedings of the 8th International Technology, Education and Development Conference, Valencia, Spain (2014) ISBN: 978-84-616-8411-3
10. Al-Wabil, A., Meldah, E., Al-Suwaidan, A., AlZahrani, A.: Designing Educational Games for Children with Specific Learning Difficulties: Insights from Involving Children and Practitioners. In: Proceedings of the Computing in the Fifth International Multi-Conference on Global Information Technology (ICCGI), pp. 195–198. IEEE CPS (2010), doi:10.1109/ICCGI.2010.43
11. AlGhamdi, N., AlOhali, Y.: Rannan: Computer Based Auditory Training For Arabic-speaking Children. In: Proceedings of the 2010 World Conference on Educational Multimedia, Hypermedia & Telecommunications EdMedia, Toronto, Canada, pp. 3225–3229. AACE (2010)
12. AlGhamdi, N., AlOhali, Y.: The Design and Development of 3D Auditory Environments for Computer-Based Aural Rehabilitation Programs. In: Proceedings of the Fifth International Multi-Conference on Computing in the Global Information Technology (ICCGI), pp. 209–213. IEEE CPS (2010), http://dx.doi.org/10.1109/ICCGI.2010.10
13. Al-Wabil, A., Al-Shabanat, H., Al-Sarrani, R., Al-Khonin, M.: Developing a Multimedia Environment to Aid in Vocalization for People on the Autism Spectrum: A User-Centered Design Approach. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A., et al. (eds.) ICCHP 2010, Part II. LNCS, vol. 6180, pp. 33–36. Springer, Heidelberg (2010)
14. Al-Wabil, A., Al-Husain, L., Al-Murshad, R., Al-Nafjan, A.: Applying the Retrospective Think-Aloud Protocol in Usability testing with Children: Seeing Through Children's Eyes. In: Proceedings of the 2010 User Science and Engineering Conference iUser, pp. 98–103. IEEE CPS (December 2010)
15. AlSuwaidan, A., AlZahrani, A., Meldah, E., AlNukhilan, H., AlIsmail, S.: Designing Software for Cognitive Training of Children with Learning Difficulties: The Memory Challenge Project. In: Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2010, pp. 737–740. AACE, Chesapeake (2010)

16. Al-Omar, D., Al-Wabil, A., Fawzi, M.: Using Pupil Size Variation during Visual Emotional Stimulation in Measuring Affective States of Non-Communicative Individuals. In: Stephanidis, C., Antona, M. (eds.) UAHCI 2013, Part II. LNCS, vol. 8010, pp. 253–258. Springer, Heidelberg (2013)
17. Al-Muhanna, H., Al-Wabil, R., Al-Mazrua, H., Al-Fadhel, N., Al-Wabil, A.: An Interactive Multimedia System for Monitoring the Progressive Decline of Memory in Alzheimer's Patients. In: Stephanidis, C. (ed.) Posters, Part II, HCII 2011. CCIS, vol. 174, pp. 381–385. Springer, Heidelberg (2011)
18. Alghamdi, N., Alhudhud, G., Alzamel, M., Al-Wabil, A.: Trials and Tribulations of Brain-Computer Interfaces. In: Proceedings of the Science and Information Conference the SAI, London, UK, pp. 212–217. IEEE CPS (2013)
19. Almazrou, H., Alzamel, N., Alwabil, R., Almuhanna, H., Alhinti, L., Al-Wabil, A.: Technology for Psychosocial Interventions for Individuals with Alzheimer's: Reminiscence Therapy and Monitoring Progressive Decline of Cognitive Abilities. In: Proceedings of the Science and Information Conference the SAI, London, UK, pp. 171–175. IEEE CPS (2013)
20. Software and Knowledge Engineering Research Group SKERG, http://skerg.ksu.edu.sa
21. Simpson, R.: Computer Access for People with Disabilities: A Human Factors Approach. CRC Press, Taylor and Francis (2013)
22. User Centered Design Process for Interactive Systems: ISO 9241 (Ergonomics of human-system interaction - Part 210), http://www.iso.org/iso/home/store/catalogue_ics