A Tablet-Based Lexicon Application for Robot-Aided Educational Interaction of Children with Dyslexia

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A Tablet-Based Lexicon Application for Robot-Aided Educational Interaction of Children with Dyslexia

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Abstract. Dyslexia is a neurodevelopmental disorder that has the highest prevalence among different types of learning disorders. Dyslexic children usually have difficulty in reading and as a result, they face different educational problems at school. Currently, social robots are widely used as educational assistants and tutors, mainly for children with special needs. The Taban robot is a modern educational social robot, which was developed specifically for dyslexic children. In this paper, an android application was designed and developed to facilitate child-robot interaction just by means of a tablet. Using this smart tablet game, the children could collaborate with the Taban social robot in solving the pedagogic problems and practicing educational concepts, while the robot provides them not only beneficial verbal and physical reactions by its hands, but also effective visual feedback on its touch screen. For the first step in this research, the acceptability of the designed tablet game was investigated for twenty-one participants that fifth of them had dyslexia. The hopeful results of the SAM questionnaires filled out by the children, demonstrate high acceptability of the tablet game. Furthermore, by implementing automatic assessment based on the designed standard criteria, the platform could meaningfully distinguish the two groups of children (dyslexic and typically developed (TD)) according to their achieved scores in the game. Thus, the high potential value of the designed robot-aided tablet game was illustrated to be used as an assistive tool for dyslexic children.

Keyword: Educational technology · Human-robot interaction · Android programming · Serious Games · Learning disabilities · Special Education

1 Introduction

Learning disorders include different types, such as dyslexia, dysgraphia, dyscalculia, and combined learning disorders, etc., with dyslexia being the most common disorder, which includes a wide range of problems in reading, writing, and mathematics [1]. Today,

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with the advent of educational technologies, various tools are used to help children with special needs, including computer games, virtual reality, social robotics, etc. that we have used in our previous studies [2–5]. Computer games have shown high potential in the treatment of dyslexia due to their personalization, anxiety-reducing features, attractive nature, multisensory components, and instant feedback [6–16].

Risqi worked on the implementation and the effect of the gamification approach on the dyslexic learning process. The game elements were grouped based on the needs of dyslexic children, desired psychological outcomes, and software requirements; and they were intended to produce specific psychological outcomes such as engagement, enjoyment, and motivation. All dyslexic children felt happy and enjoyed playing. An average of 96.64% agreed to use the application again [6]. Martins et al. presented an application that applies voice recognition on mobile devices for training and diagnosis of dyslexic people. The application displays a random word for the user to read and verifies the correctness of the spoken word. Preliminary results indicated that the application was able to diagnose traces of dyslexia; however, the tests were held just once [7]. Vasalou et al. studied the effectiveness of the tablet game "Words Matter", which contains various mini-games for enhancing word recognition and spelling. The results showed children spontaneously engage in 'game talk', which facilitates a strong sense of social engagement, enforces self-confidence, and creates a variety of new opportunities for learning by sparking tutor and student-initiated interventions [8].

Borhan et al. developed a mobile application, "Mr. Read" that utilizes a sight-word reading strategy to help dyslexic children. This strategy is incorporated into three different modules in the application: short stories, rhymes, and song verses. The overall results of the tests illustrated that 100% of respondents, instructors, parents, and children either agreed or strongly agreed that this mobile application can improve reading skills [9]. Zare, et al. investigated the effect of Persian-language word exercise games on the spelling of dyslexic students. Children took pre-test and post-test, and spelling was improved in the experimental group compared to the control group [10].

Ecalle et al. evaluated the short and medium-term effects of "ChassymoDys" software on improving phonemic awareness, decoding, and word-reading skills in French poor readers. Analyzing 12 children in 3 levels, they validated the guess that digital solutions can help children learn better and faster, especially in short practice periods [11]. Burac et al. developed a mobile assistive application, "IREAD", which primarily implements text-to-speech technology to enhance the reading capability of learners with dyslexia. The usability results of the application showed the participants strongly agreed with all usability dimensions [12]. Brennan et al. examined if code signing a game, "Cosmic Words", with children improves the teaching of phonological awareness skills. The result was that children were more invested in using these games for learning. There was a positive impact on their phonological awareness skills while their engagement in learning increased [13].

The software presented by Kariyawasam et al. used machine learning methods for dyslexia screening. Trained convolutional neural networks were used to detect the spoken or written letter/word or number on the mobile application. The application was tested among pre-diagnosed children with learning disabilities and the results reached 89% accuracy, but tests need more time to be completed [14]. Khaleghi et al. examined gamification and serious game approaches efficacy in improving 6–8 year-old dyslexic children's motivation to complete cognitive rehabilitation interventions like phonological awareness. The result indicated that games improve children's learning process and increase their motivation. The limitation was that the questionnaires were filled only by supervising experts and not the children [15].

Despite the large number of studies on the effectiveness of computer games on dyslexia, social robots have been used in relatively few studies in this field using just the NAO and QT robots [16–18]. Taban 2 (called Taban in this article and a new generation of the Taban [19]) is a social robot that has been specifically constructed for the educational practice of children with dyslexia. In most social robotic research, tablets and touch screens are the favored auxiliary interactive tools, especially when automatic speech recognition is not appropriately robust for child-robot interactions [20].

In this paper, a modern android game and social robotics technologies were combined to provide a novel protocol; a new tablet game collaborating with the Taban autonomous social robot, which provides visual, verbal, and physical feedback for the child, to improve the literacy and reading skills of children with dyslexia. To explore the potential of this tablet game for the rehabilitation and improvement of children with dyslexia, first of all, we study the acceptability in this research. Moreover, we would also study whether there is a significant difference between the performances of the two groups of participants (i.e., dyslexic and TD), which signalizes the effectiveness of the tablet game as an educational intervention tool for children with dyslexia.

2 Methodology

The first step in game design is the cognitive functions that we target for improvement or treatment in dyslexic children, which should be clearly defined. The game and the child-robot interactions were designed based on the selected etiology theory of dyslexia. Several different theories explain the origin of dyslexia, including auditory processing deficits, verbal working memory deficits, visual magnocellular deficits, phonological processing deficits, and cerebellar dysfunction [21].

This study focuses on phonological processing and phonological awareness deficits due to their high prevalence and specificity as an underlying cause of dyslexia, not just a symptom of other cognitive disorders [22, 23]. The phonological processing deficit theory holds that representing, storing, or retrieving speech sounds is impaired in dyslexia [24]. This theory guides the interactions and several mini-games were designed based on the theory and its related therapeutic exercises.

Before designing any child-robot interactions, we observe all exercises, training, and treatments provided for dyslexic children in the learning disorder centers. By observing these exercises, we learned what capabilities the robot-aided application needed to be used as an assistant to the conventional learning techniques of the teachers.

2.1 Participants and Experimental Setup

The participants in this study were elementary school students, including both typically developing (TD) children and children with dyslexia. Each child took part in only one session. The dyslexic group consisted of 5 children (5 boys) with an average age of 7.40 years (SD = 0.49). The TD group had 16 children (14 boys, and 2 girls) with an average age of 7.38 years (SD = 0.78).

In the acceptance session, after the initial greeting, the robot provides explanations for the participants about the rules of using the tablet and answering questions, and then in the first step, the robot itself solves a question so that the children can practically learn the protocol. Then the robot asks the children to answer the questions carefully. The sessions lasted 20–40 min per child based on the level of his/her knowledge (Fig. 1(a)). During the interactions with the robot and answering the question, the children's performance was evaluated. The participants had no prior experience with robot-assisted learning methods and at the end of the session, they filled out a questionnaire.

2.2 Game Design

Eight interactive lexical games were designed for both dyslexic and non-dyslexic children. The games are displayed on two devices including an LCD screen on the Taban robot, and a tablet in front of the child. The child only interacts directly with the tablet, not the robot, so as to protect the robot from possible danger. However, the tablet forwards the child's responses to Taban, which provides interactive audio-visual feedback to the child based on their answers. This includes responding through the speakers, screen, and physical movements of its head and arms. The robot's interactions give feedback on whether the child's responses are correct or incorrect.

The eight games are run on the tablet and target different areas in lexical study. Each game focuses on one or more specific areas, with an increasing levels' difficulty. The games utilize audiovisual components to teach vocabulary. On the tablet, words are represented by some pictures that the child must select them. Some games require choosing multiple images, occasionally in a particular order. This multimedia approach allows the games to cover a broad range of lexical topics while remaining engaging through interactive play.

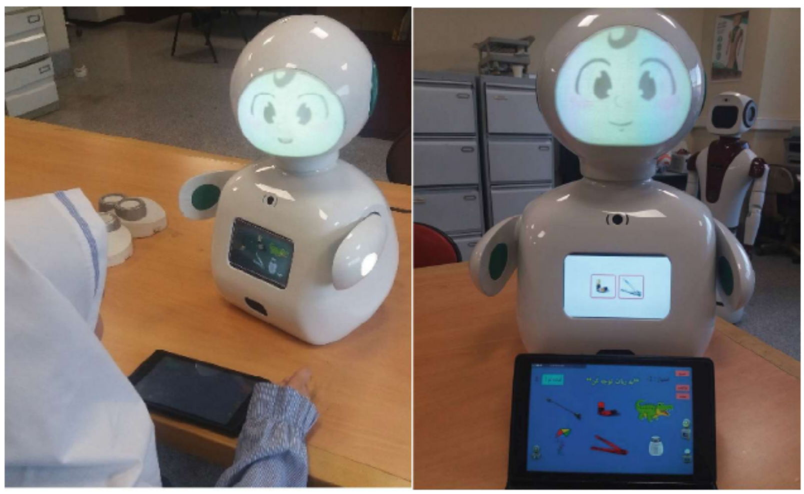
The Taban robot assists the tablet games in several ways:

- Taban provides gentle spoken instructions and feedback through speakers on its head. This includes a short explanation at the start of each game, as well as remarking on the validity of the child's responses during the gameplay to further guide them.
- Taban uses expressive physical gestures like moving its arms and head to indicate if the child's tablet answers are correct or incorrect. This supplements the feedback already displayed on the tablet screen.
- An animated face projected onto Taban's head gives the robot more human-like expressions and characteristics.
- Taban displays dynamic pictures related to the game and the child's answers on an attached LCD screen on its chest. The images are color-coded and blink green for correct responses or red for incorrect ones, providing additional visual feedback (Fig. 1(b)).

In addition to help from Taban, the child may ask for further guidance if they find the game difficult at first. In total, four classes of games will be discussed in the coming sections.

2.2.1 Recognition of the First Phoneme

Games 1 and 2 focus on phonology and phonetics. They involve recognizing and comparing the initial phonemes of words represented as images on the tablet. In Games 1 and 2, the child must select pictures depicting words that start with a specified phoneme. Game 1 displays six images to choose from in groups of two. Game 2 increases the difficulty by providing nine images in groups of three (Fig. 2(a)).



a) b)

Fig. 1. a) The children interact with the robot and answer questions via tablet in the acceptance session, b) The LCD touch screen attached to Taban's chest displays the animated picture with red color for an incorrect response.

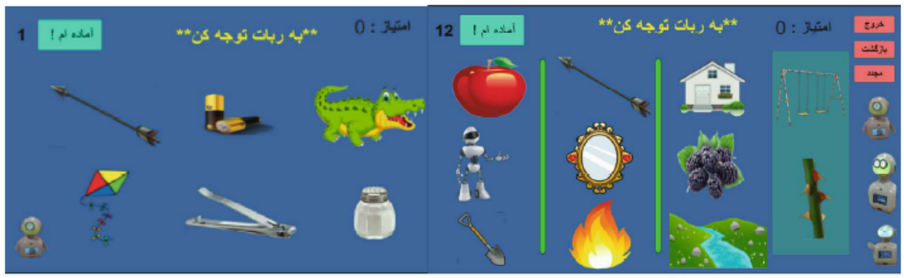
2.2.2 Initial Phoneme Manipulation

Games 3 and 4 target morphology and word formation processes. They require the child to remove or alter the initial phonemes of words represented by the pictures. In Game 3, the child must identify the new word created when the first phoneme is removed from another word. Game 3 displays three images on top that the child removes phonemes from, matching to one of the three images on bottom. Game 4 increases difficulty with 6 shuffled images to choose pairs from. The levels progressively challenge children's skills.

2.2.3 Phonological Composition and Intersection

Games 5 and 6 target phonological processing and psycholinguistics skills. They involve decomposing and sequencing phonemes within words represented by images. In Game 5, three images in a column on the right represent 3-phoneme words. The child must extract the component phonemes from each word, and then select images on the left that start with those phonemes in the correct order (Fig. 2(b)).

Game 6 begins with Taban reading the component phonemes of the four words aloud in sequence. The child must construct the words in their mind and remember them. After all phonemes are read out, the child selects the corresponding images in the correct order. This game adds a working memory component for increased difficulty.



a) b)

Fig. 2. Screenshot of the game questions: a) Game 1: A set of correct answers would be the crocodile [تمساح]and arrow [تیر], both starting with the [ت]phoneme. b) Game 12: The phonemes of the word swing [تاب]in order are [ت], [آ], and [ب]. In order these are the first phonemes in the words: mulberry [توت], mirrors [آیینه]and shovel [بیل]. These images need to be selected in order.

2.2.4 Syllabic Awareness

Games 7 and 8 focus on syllabication and phonological segmentation skills. They involve deconstructing words represented by images into their component syllables. Game 13 has multiple parts. Two 2-syllable words are displayed in a column on the right as images; and on the left there are 5 images with numbered labels below them. The child first identifies which left images contain syllables in the right words. They specify the syllable number of each left image using the labels. This breaks down the words into syllables. Then the child selects the left syllables constructing each word on the right in order.

The final game requires selecting images of words with the same number of syllables. Twelve images in groups of three represent 1, 2, and 3-syllable words to be chosen together. Through syllabication and segmentation, these games develop phonological awareness. The multi-step format of Game 7 provides a deep practice. Game 8 challenges children to apply skills to new vocabulary.

2.3 Database

In addition to the predefined game levels, there is also a randomized mode utilizing a database of 1000 common elementary school words. This database was constructed by extracting phonetic and syllable data, plus image files, for each word using phonetic dictionaries, automated tools, and manual processing. With this database, randomized versions of the games can be dynamically generated following the same principles as the leveled games. For instance, iterating through all words and pulling ones sharing the same initial phoneme can create randomized phonology and phonetics games matching games 1 and 2.

The database allows essentially endless permutations of the vocabulary games within the four learning categories. This adds variety and engagement for children replaying the games. A prototype for this has already been developed; however, since a repeatable experimental setup is required, no children were asked to participate in them.

2.4 Assessment

The children were assessed in two ways. First, an automatic assessment system was designed to grade children's performance based on the speed, accuracy, and number of incorrect responses during the games. Specific metrics tracked included:

- Response time for finishing a game
- Number of times an incorrect response was submitted before finishing the game

It should be noted that a game is considered "finished" once all correct answers are submitted. Performance data was logged in real-time during the gameplay. Automated methods then calculated scores based on the recorded metrics. Second, the participants' emotional reactions were evaluated after completing the game activities using the Self-Assessment Manikin (SAM) scale. The SAM uses non-verbal pictorial assessments of pleasure, arousal, and dominance; it has been used in several acceptance studies in the field of social robotics [25, 26]. Children selected the SAM images that best represented their experienced emotions during the gameplay.

3 Results and Discussion

The participants filled out the SAM questionnaire and determined their level of acceptance of the game at the end of the experiment session (Table 1).

Table 1. The mean and standard deviation scores of the SAM questionnaire parameters and the T-value and P-values associated with the T-tests.

No	Item	SAM Questionnaire			
		Score's mean (SD)		T_Value	P_Value
		Dyslexia	Normal		
1	Pleasure	4.6 (0.49)	4.75 (0.43)	−0.601	−0.56
2	Arousal	4.8 (0.4)	4.63 (0.6)	0.506	0.69
3	Dominance	4.6 (0.49)	4.75 (0.56)	0.61	−0.53

According to the results in Table 1, both dyslexic and normally developing children showed high levels of arousal, dominance, and pleasure. These results show both groups felt engaged with the robot-aided games, and were happy, excited, and felt in control while playing them. Also, it could be understood that there is no significant difference in the acceptance rate of the game between groups.

Furthermore, the participants' performances were assessed during the games and their final scores were calculated based on their reaction time and the correctness of their answers (Table 2). Additionally, another purpose of this part of the study is to determine if there is a significant difference between the performances of the typically developing students and those with dyslexia in doing the designed exercises.

Table 2. The mean, standard deviation, and Cronbach's alpha scores of the dyslexic and TD groups in different exercises and the T-value and P-values associated with the T-tests; P-value < 0.05 shows the 95% confidence interval.

No	Item		Total Score Out of 20 (SD)		P-value	T- value	Cronbach's alpha
			Dyslexia	Normal			
1	Recognition of the First Phoneme	Game 1	7.65 (4.16)	13.53(4.12)	**0.032**	−2.77	**0.771**
		Game 2	4.03 (4.58)	9.76 (5.08)	**0.049**	−2.38	
		Total	**5.84 (5.77)**	**11.64 (4.84)**	**0.009**	−2.8	–
2	Initial Phoneme Manipulation	Game 3	5.31 (4.15)	12.43 (4.32)	**0.016**	−3.32	**0.895**
		Game 4	5.71 (6.28)	13.17 (3.38)	0.064	−2.54	
		Total	**5.51 (5.39)**	**12. 8 (3.88)**	**0.001**	−5.52	–
3	Phonological Composition and Intersection	Game 5	6.27 (7.9)	7.61 (7.57)	0.749	−0.34	0.63
		Game 6	2.84 (6.54)	9.51 (7.13)	0.093	−1.95	
		Total	**4.55 (5.95)**	**8.56 (6.71)**	**0.026**	−2.44	–
4	Syllabic Awareness	Game 7	4.68 (8.02)	9.36 (3.09)	0.271	−1.27	**0.796**
		Game 8	5.23 (4.67)	9.49 (4.16)	0.118	−1.82	
		Total	**4.96 (6.19)**	**9.42 (3.61)**	**0.055**	−2.17	–

The results in Table 2 clearly illustrate that the performance of the typically developing children is significantly higher than the children with dyslexia for all of the total items (total P-value < 0.05). Considering the significant performance difference between normal participants and children with dyslexia, it could be concluded that the exercise designers had enough data and a good comprehension of children with dyslexia and their capabilities to design efficient exercises. Furthermore, this result is a hopeful signal illustrating that this game might have the potential to be used for screening dyslexic children and to identify them by measuring their performance in this robot-aided table game. In addition, Cronbach's alpha scores for almost all game groups (>0.7) show good reliability and internal consistency in results. As a result, our hypothesis of merging these four related types of questions together and examining the significant difference in the combined results of all of them is correctly confirmed.

3.1 Limitations and Future Works

The small number of the dyslexic participants and the unbalanced distribution of the male/female participants in both groups are the limitations of this study. Additionally, due to the high acceptance rate of the designed game, the next step is to conduct systematic educational interventions (e.g. over at least 8 sessions) based on similar studies with a group of dyslexic children. The aim is to assess the effectiveness of the designed robot-aided tablet game protocol in improving the phonological awareness and reading skills of children with dyslexia.

4 Conclusion

The main goal of this research was to introduce a robot-aided serious game as a novel method of education for children with dyslexia based on their special educational needs. The robot could be used as tutor in this protocol and increase the motivation, productivity, and learning rate of children with dyslexia. This study presented the four classifications of games and their contents, as well as evaluating their acceptability.

In addition to automated grading tools for each game, the SAM scale was used to assess the participants' emotional reactions. The results showed that the designed tablet game might have the potential to be used as a screening tool for dyslexic children while giving them a similar level of enjoyment to non-dyslexic children while playing.

In summary, the protocol of an engaging robot-aided tablet game presented in this study shows high potential for helping children with dyslexia and could serve as a valuable tool to assist teachers with their conventional teaching methods.

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References

1. Vahia, V.N.: Diagnostic and statistical manual of mental disorders 5: a quick glance. Indian J. Psychiatry **55**(3), 220 (2013)
2. Taheri, A., Shariati, A., Heidari, R., Shahab, M., Alemi, M., Meghdari, A.: Impacts of using a social robot to teach music to children with low-functioning autism. Paladyn J. Behav. Robot. **12**(1), 256–275 (2021)
3. Ghorbandaei Pour, A., Taheri, A., Alemi, M., Meghdari, A.: Human–robot facial expression reciprocal interaction platform: case studies on children with autism. Int. J. Soc. Robot. **10**, 179–198 (2018)
4. Shahab, M., et al.: Utilizing social virtual reality robot (V2R) for music education to children with high-functioning autism. Educ. Inf. Technol. 1–25 (2021)
5. M. Tavakol Elahi et al., Xylotism: A Tablet-Based Application to Teach Music to Children with Autism. in Social Robotics: 9th International Conference, ICSR 2017, Tsukuba, Japan, November 22–24, 2017, Proceedings 9: Springer, pp. 728–738, 2017

6. Risqi, M.: LexiPal: design, implementation and evaluation of gamification on learning application for dyslexia. Int. J. Comput. Appl. **131**(7), 37–43 (2015)
7. Martins, V.F., Lima, T., Sampaio, P.N.M., De Paiva, M.: Mobile application to support dyslexia diagnostic and reading practice. In: 2016 IEEE/ACS 13th International Conference of Computer Systems and Applications (AICCSA), November 2016
8. Vasalou, A., Khaled, R., Holmes, W., Gooch, D.: Digital games-based learning for children with dyslexia: a social constructivist perspective on engagement and learning during group game-play. Comput. Educ. **114**, 175–192 (2017)
9. Borhan, N.H., et al.: An enhancement of dyslexic mobile application using sight word reading strategy: results and findings. J. Comput. Sci. **14**(7), 919–929 (2018)
10. Zare, M., Amani, M., Sadoughi, M.: The role of Persian-language word exercise games in improving spelling of students with dyslexia: word exercise games in improving spelling. J. Comput. Assist. Learn. **36**(3), 315–322 (2019)
11. Ecalle, J., Vidalenc, J.-L., Ballet, C., Magnan, A.: From fundamental research to the design of a software solution to help poor readers. J. Educ. Comput. Res. **58**(2), 297–318 (2019)
12. Burac, M.A.P., Dela Cruz, J.: Development and usability evaluation on individualized reading enhancing application for dyslexia (IREAD): a mobile assistive application. In: IOP Conference Series: Materials Science and Engineering, vol. 803, no. 1, p. 012015, April 2020
13. Brennan, A., McDonagh, T., Dempsey, M., McAvoy, J.: Cosmic sounds: a game to support phonological awareness skills for children with dyslexia. IEEE Trans. Learn. Technol. **15**(3), 301–310 (2022)
14. Kariyawasam, R., Nadeeshani, M., Hamid, T., Subasinghe, I., Ratnayake, P.: A gamified approach for screening and intervention of dyslexia, dysgraphia and dyscalculia. In: 2019 International Conference on Advancements in Computing (ICAC), December 2019
15. Khaleghi, A., Aghaei, Z., Behnamghader, M.: Developing two game-based interventions for dyslexia therapeutic interventions using gamification and serious games approaches entertainment computing journal. Entertain. Comput. **42**, 100482 (2022)
16. Papadopoulou, M.T., et al.: Efficacy of a robot-assisted intervention in improving learning performance of elementary school children with specific learning disorders. Children **9**(8), 1155 (2022)
17. Karageorgiou, M.E., et al.: Development of educational scenarios for child-robot interaction: the case of learning disabilities. In: Merdan, M., Lepuschitz, W., Koppensteiner, G., Balogh, R., Obdržálek, D. (eds.) Robotics in Education. RiE 2021. AISC, vol. 1359, pp. 26–33. Springer, Cham (2022). https://doi.org/10.1007/978-3-030-82544-7_3
18. Azizi, N., Chandra, S., Gray, M., Sager, M., Fane, J., Dautenhahn, K.: An initial investigation into the use of social robots within an existing educational program for students with learning disabilities. In: 2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), pp. 1490–1497. IEEE (2022)
19. Mokhtari, M., Shariati, A., Meghdari, A.: Taban: a retro-projected social robotic - head for human-robot interaction. In: 2019 7th International Conference on Robotics and Mechatronics (ICRoM), pp. 46–51, November 2019
20. Belpaeme, T., Kennedy, J., Ramachandran, A., Scassellati, B., Tanaka, F.: Social robots for education: a review. Sci. Robot. **3**(21), eaat5954 (2018)
21. Baddeley, A.: Working memory: looking back and looking forward. Nat. Rev. Neurosci. **4**(10), 829–839 (2003)
22. Pérez-Quichimbo, S.-M., Navas-Moya, M.-P., Montes-León, S.-R., Sambachi-Chilig, P.-A., Barrera-Quimbita, E.-D.: Therapy using serious games to improve phonological awareness in children with functional dyslexia. In: Botto-Tobar, M., Montes León, S., Torres-Carrión, P., Zambrano Vizuete, M., Durakovic, B. (eds.) Applied Technologies. ICAT 2021. CCIS, vol. 1535, pp. 121–134. Springer, Cham (2022). https://doi.org/10.1007/978-3-031-03884-6_9. Accessed 17 Aug 2023

23. Ramus, F.: Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. Brain **126**(4), 841–865 (2003)
24. Syrdal, D.S., Dautenhahn, K., Robins, B., Karakosta, E., Jones, N.C.: Kaspar in the wild: experiences from deploying a small humanoid robot in a nursery school for children with autism. Paladyn J. Behav. Robot. **11**(1), 301–326 (2020)
25. Shariati, A., et al.: Virtual reality social robot platform: a case study on Arash social robot. In: Ge, S., et al. (eds.) Social Robotics. ICSR 2018. LNCS, vol. 11357, pp. 551–560. Springer, Cham (2018). https://doi.org/10.1007/978-3-030-05204-1_54
26. Bradley, M.M., Lang, P.J.: Measuring emotion: the self-assessment manikin and the semantic differential. J. Behav. Ther. Exp. Psychiatry **25**(1), 49–59 (1994)