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IN SEARCH FOR A VIABLE PEDAGOGICAL AGENT IN ASSISTIVE APPLICATIONS FOR DYSLEXIC CHILDREN

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ABSTRACT

TO attend to dyslexia, many studies have been conducted, and in the frontline is the design of assistive applications for dyslexic children. However, studies have not been focused on the nature and appearance of these pedagogical agents used in assistive applications, especially considering children's preferences and their users' experiences. Hence, this study employs Systematic Literature Review (SLR) methodology to collate and analyse the research-based and publicly-available assistive applications designed for dyslexic children. The findings present two categories of virtual assistants used in the analysed assistive applications, which are girl-like and animal-like objects. This girl-like object is used by 83.3% of the analysed works. We then proceed with and on-site experiment to collect the dyslexic children's preferences. The result showed that boy-like objects are much more preferable, depending on their gender, which contradicts with previous works that present girl-like objects as avatar most of the time.

Keywords: Girl-like object; animal-like object; children preferences; pedagogical agent.

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1. INTRODUCTION

Dyslexia is a language-based learning disability which results in incapability to distinguish sound components [1]), or properly identify alphabets [13]. Although the main cause has not

been comprehensively identified [23], its characteristics are poor verbal fluency, short-term memory, difficulty in sequencing and writing [8,13]. [1] also observed that persons with dyslexia can experience lack of organisational skills and time management which can equally have negative effect on their learning process. In view of attending to dyslexia and correcting its learning disorderliness, numerous studies [3,6,20,27] have been conducted. These studies range from identification of dyslexic children (DC) [7], analysis of physiological features of dyslexics [20,26], and more importantly, design of assistive applications for the dyslexics [3,6,18,21,24,27]. In the design of assistive applications for the DC, pedagogical agents or virtual assistants (VA) – which are either in the form of avatar, mascots or robot – are often employed to guide the users through the exercises and processes designed to correct dyslexia. However, studies have not focused on the nature and appearance of these pedagogical agents, as it attends to the children's preferences and enhance their usage experiences.

This study therefore aims at investigating the children's preference of VA to be used in the design of an assistive application for the DC. To achieve this, this study analyses (1) the research-based and publicly-available assistive applications designed for children with dyslexia through a systematic literature review (SLR) methodology; and (2) the children's preferences during on-site experiment. It therefore proposes the most viable VA type as found in both, the literature review and the children's preferences.

This study is stemmed from our research on designing assistive applications for children with dyslexia using automated speech recognition (ASR) and interaction design models. Our assistive application, *BacaDisleksia*, is designed for Malaysian DC within the age of 5 to 14 years. In designing *BacaDisleksia* (depicted in Figure 1), where we used robot-like object as the VA, we realised that no literatures are available to support the choice of VA, compared to instances of choosing colour, font size, and style. We opine that children's preferences should inform the choice of VAs in assistive applications for DC. This will arguably enhance the users' experiences, and support the correctional functionality of the assistive application. This study is a step towards attending to the observed gap. It is crucial to tap into their interests and what motivates them to learn to read as we have observed that their preferences (of background colours and text colours) have shown to facilitate them to read correctly. Thus, this study contributes to finding the best, most suitable reading VA for

dyslexic children. Using the wrong VA might just demotivate them to read or simply discourage them to do so.

Fig.1. Baca Disleksia

2. METHOD

This study uses (1) Systematic Literature Review (SLR) in analysing the research-based and publicly available assistive applications designed for dyslexic children; and (2) on-site experiment in gathering primary data on the children's preferences for pedagogical agents found appealing to them. SLR is a method for identifying, evaluating and interpreting available information regarding a particular topical question or research interest [14]. SLR defines the review protocol by specifying the topic and method of conducting the review [11]). This study adopts the three-stage phases in SLR which are planning the review, conducting the review, and reporting the review.

The planning-the-review phase is to gather related sources of information on assistive applications for DC. We chose IEEE explore and ACM as digital libraries for an objective information search and gathering. Phrases used as search keywords are: "assistive technology" + "dyslexic children"; "assistive applications" + "children" + "dyslexia" for both digital libraries. A period of 15 years, which is from 2001 to 2015, is chosen to filter out stale works and ensure we mainly focus on current trends. A total of nineteen (19) and twenty-three (23) articles were sorted from the IEEE explore and ACM digital library respectively.

The conduct-the-review phase was done by adapting Population-Intervention-Comparison-Outcome-Context (PICOC) method [4]. The general theme of the articles used in the systematic review is the population, while the general point rallied by the reviewed studies is the intervention. The comparison, as adapted by this study, is the feature analysis of the

elicited VA in the analysed assistive application. The outcome highlights the findings of this analysis, and the context describes the implication of the findings for the research objective. Table 1 presents the PICOC review method.

Table 1. PICOC review method.

Population	Intervention	Feature Analysis	Outcome	Context
Assistive applications; dyslexic children	Assistive applications for dyslexic children	Analyse the features of the VAs in terms of object type.	The viable choice among the VAs, as determined by frequency of its usage in the analysed studies.	The nature and appearance of the VAs that the children prefer and enhance their usage experiences.

Articles on assistive technologies and application and dyslexic children are the population of this study's SLR. The intervention highlights the design of assistive technologies and applications for children with dyslexia. This specifically takes into consideration, the nature of the objects used as VAs in these assistive applications which will be determined by the feature analysis of the accessed VAs used in the design of research-based and publicly available assistive applications for children with dyslexia.

3. On-site experiment

Utilising the finding, we move on further by designing four other pedagogical agents as avatars in order to confirm the finding obtained from the SLR. Those agents are boy object, robot, alien, and dinosaur (refer to Figure 3).

 Girl-like object	 Boy-like object	 Robot	 Alien	 Dinosaur

Fig.3. Five different pedagogical agents were tested during the experiment.

The procedure of the experiment is as follows:

Step 1 The demographic information of each DC is recorded including their names, age, and gender.

Step 2 Each DC is presented with five different pedagogical agents as shown in Figure 3.

Step 3 Each DC is asked to choose their preference by giving rankings to the four agents.

Step 4 The ranking by DC is recorded on a data collection sheet, listing the most likable agent to the least likable one.

Step 5 Each DC is also asked questions on their favourite stories/movies/ cartoon shows, favourite games, and favourite teacher's characteristics.

Step 6 The conversation between researcher and each DC is recorded for future reference.

4. Findings: SLR

The conduct-the-review phase of the SLR is done by reviewing the articles sorted from the digital libraries. In the case of the IEEE explore, there are cases of same search result and suitability. Finally, twelve (12) articles were reviewed. In the case of ACM digital library, there are also cases of same authors and repetitions, seven (7) articles were reviewed. This brought the total number of articles reviewed to be nineteen (19), and this is presented in Table 2 below.

Table 2. Results obtained from the SLR.

Application [Author]	**Age Suitability**	**Remark (Publicly available/Not publicly available)**
Spatial Math Tutor [16]	Elementary school students. No specific age mentioned	Not publicly available
Dyslexia Activity System (DAS) [18]	No age specification made	Not publicly available
JollyMate [13]	No age specification made	The work is not publicly available. Also, it treats dysgraphia as an associated disorder to dyslexia
Belajar Membaca [25]	No age specification made	No public availability link is provided. However, the screenshots show that no VA/mascot is used for the prototype
Dycover [21]	No age specification was made, but claim was made to pre-school students	No publicly accessible link. The screenshots provided in the article shows that avatar/VA is not used.
MathLexic [2]	No age specification was made.	There were screen shots provided in the article, but no VA is used.
Learn-to-Read [24]	5 – 7 years old	Screenshots of the application provided in the article show that VA is not employed
Dyslexia Friendly Reader [15]	10 – 11 years	No VA is employed as shown in the screenshots presented in the article
DysWebxia [23]	No age specification is made	There is no VA employed.
MyLexic [1]	No specific mention of the age bracket	There is no VA object used in the application.
SpellBound [26]	8 – 12 years	There is no VA object used in the application.

Tactile Letters [9]	5-6 years old	Publicly available, but there is no VA object used in the application.
PhonoBlocks [5]	5 – 8 years	It has no VA because it is tangible blocks for reading exercise for the dyslexic students
SmartLexic [7]	7 – 9 years children at early primary school	The screenshots show that the VA is a girlsque object/avatar shape.
Bijak Membaca [3]	7 – 8 years	The screen shots of the application provided in the article show that the VA is girlsque objects of two different styles.
Dyslexia Baca [6]	4- 7 years	The screenshots were provided in the article. The VA is also girlsque object.
Madrigale [27]	7 – 9 years	A screenshot of the application interface is provided, and this shows many VAs of girlsque icon.
Dyseggxia [22]	No age specification is made	It is publicly available. From the screenshot provided in the article, the VA used is of animal object. Specifically it is a Penguin with evolutionary growth represented by respective images.
Translator Website [19]	For children, but with no mention of the age specification	The article shows a girlsque object as the VA – where applicable.

This review presents SmartLexic [7], Bijak Membaca [3] Dyslexia Baca [6], Madrigale [27], Dyseggxia [22], and Translator Website [19] as the analysed assistive applications which employed pedagogical agents/VA in their respective design. The two categories of the pedagogical agents used in the analysed assistive applications based on their characterisation are girlsque girl-like [3,6,7,19,27] and animal-like objects [22]. This makes the usage of the girlsque (girl-like) and animal-like object to be of 83.3 and 16.7 percent respectively.

5. Findings: On-site Experiment

To confirm our SLR, we seek to find out the preferences of real DC in the on-site experiment. Five DC participated and their preferences are captured. Interestingly, the results showed an obvious contrast to the findings in SLR where girl-like objects are the most common and preferred to be portrait as pedagogical agent. Our findings reveal that the most preferred agent is the boy (refer to Figure 3). The detail findings are tabulated in Table 3.

Table 3. Dyslexic children's preferences on pedagogical agent

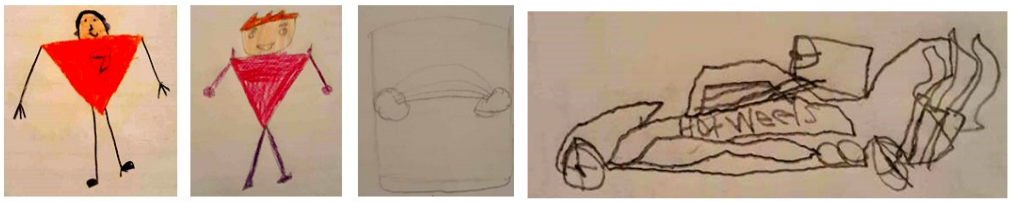
DC	Gender	Age	Preference 1	Preference 2	Preference 3	Own proposal
1	Male	8	Dinosaur	Robot	Alien	None
2	Male	8	Boy	Robot	Dinosaur	A boy
3	Male	8	Boy	Alien	Dinosaur	A boyish superhero
4	Female	11	Girl	Alien	Robot	A book
5	Male	10	Robot	Alien	Dinosaur	A hot wheel car

As can be seen in Table 3, the boys prefer boyish objects such as the boy, the robot, and the alien. The girl however, chose the girl-like object because it is a girl and it is cute. The least favourite to the girl is the boy-like object (refer to Figure 3) because she dislikes boys. One DC, who is a boy, refused to even select the girl-like agent as his last choice. Two DC, a girl and a boy, chose the robot agent because they like robots.

6. Analysis

The SLR concludes two viable pedagogical agents namely girl-like object and animal object, with the girl-like object offers a much higher score of 83.3%. The on-site experiment however tells a different story all together, making this an interesting study to be conducted further. The girl-like objects often portrait as pedagogical agents might not be based on any real preferences of the children when designing an agent for assistive technology, perhaps assuming that girl-like object is more suitable to play the role of a teacher rather than a friend

in assistive technology. However, it can be seen that from the DC's preferences, boyish objects are more appealing to them (as most DC are boys than girls in numbers). Figure 5



shows their proposed agents.

Fig.5. The pedagogical agents proposed and drawn by the DC

A more 'gender-free', neutral object could be of top preference when designing an assistive technology for DC. These objects include, in our perspective, dinosaur, robot, or alien as compared to girl or boy, a princess or a superhero. In general, from Table 3, the most frequent object to be selected as number one is the boy, followed by the alien, and finally in third choice the dinosaur. Another interesting point to note is their suggestion of a pedagogical agent they would like to have, if they can replace the given choices – two of the boys chose to draw a boy and a boyish superhero (which look very similar) and one boy preferred to have a *hotwheels* car instead. The girl chose a book. None of them give any reason as to why they chose the particular objects, apart from the reason that they just like what they proposed. Obviously, boys and girls have different preferences – boys with boy-like objects and girls with girl-like objects. The result of this on-site experiment is as expected (although in contrast with the SLR). An interesting point to note is that the boy agent and the girl agent is either ranked at first place or the last place, depending on the gender of the children making the choices. It reveals that at this age, boys will prefer boyish objects and likewise, the girls will prefer girlish object. The second most preferred agent is the alien followed by the dinosaur, which can be considered as neutral or 'gender-free' objects. Although there are four boys and a girl in this experiment, it resembles the real scenario where males are higher in number in reading difficulties as compared to girls.

7. DISCUSSION

Designing an application for DC must include key components that are important for educational content. It is a challenge to all designers because DC, with their reading, spelling, and writing problems, can easily become demotivated when they do not feel they are reaching their potential or when they compare themselves with their peers and siblings. In this contribution we are proposing a VA, an avatar that can assist the DC in reading the words and sentences being displayed in the main display area of an application. The avatar should support the children via speech interface, and works to reduce distractions while also engaging, entertaining, and educating children. When applied in an application, this assistant enables parents and teachers to plan for strategies to help DC overcome and circumvent some of their difficulties.

However, an 'ideal' avatar for the DC cannot be found in the literature. Seemingly previous studies have not focused on the nature and appearance of these VAs although it is generally accepted that those characteristics could effectively assist DC reading while at the same time enhance their usage experiences. With the SLR methodology performed, we now are able to identify the mostly used object as reading assistants in DC-related applications. Our findings point to girlsque and animal-like objects as the most used avatar. The findings contradict with existing fact that dyslexia affected more males compared to females [10,12]. That is why we performed the on-site experiment to further clarify this issue. The experiment showed that boys will prefer boy-like objects and girls will prefer girl-like objects. Nevertheless, it is a start for such work that would potentially suggest towards customizable avatar for a reading assistant that meets the DC's preferences when using and interacting with such application. Still, the issue of lack of study on DC's preferences towards the suitable avatar for a reading assistant lingers. This opens a window of opportunity to further improve this analysis and enhance it in terms of proposing a better, more appealing design for an enhanced user experiences and interactions with such applications.

8. CONCLUSION AND FUTURE WORK

This study presents the SLR result and on-site experiment result in selecting pedagogical agent to be used in assistive applications for dyslexic children. SLR depicted girlsque (girl-like) object as a suitable pedagogical agent and this is interestingly contradict to the findings

of the on-site experiment. Based on the literatures collated from IEEE explore and ACM digital library, it is found out that girl-like and animal-like objects are both used as avatars in the analysed research-based and publicly available assistive applications designed for dyslexic children. However, the girl-like object earns a frequency percentage of 83.3, against 16.7 percent of the animal-like object type. Taken into account the SLR result we then compare with on-site experiment result where we found that boys prefer boy-like object to be pedagogical agent and girls prefer girl-like object, hence suggesting for a customizable agents rather than custom made. The finding therefore suggests, however hypothetically, that studies have found the 'gender-neutral' objects (such as dinosaur or aliens) to be more befitting as pedagogical agents in the design of assistive applications for dyslexic children based on the argument that only boys will select the boy agent and only girls will select the girl agent. Our future work will be users' experimental study to observe and investigate the intrinsic qualities of 'gender-neutral' object as pedagogical agents in assistive applications, and how it influences the children's experience.

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