CONFERENCE PROCEEDINGS

RPIC | REDESIGNING PEDAGOGY INTERNATIONAL CONFERENCE 2022

Transforming Education & Strengthening Society

2022

30 May - 1 June

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The impact of COVID-19 pandemic on learning Chinese at home of dyslexic students

Fung Ka Yan and Fung Kwong Chiu

Hong Kong University of Science and Technology, Hong Kong SAR

Abstract

The COVID-19 epidemic posed a significant challenge globally. Inevitably, our life setting is forced to change suddenly due to this virus outbreak, especially in education. Classes have ceased since July 2020 in Hong Kong, while half-day classes resumed from June 2021. Students could neither receive proper language training at school nor at home during the class suspension period. Digital learning could be a better support to dyslexic students during the epidemic. This study aims to find out (1) the games dyslexic students prefer, (2) the performance of writing games, (3) language games, and (4) audio games when they use digital learning tools at home. The result showed dyslexic students prefer Game Type 2, they wrote faster, and their handwriting performance has improved after four-month training. The performance difference between dyslexic and non-dyslexic students in language games is narrowed. Yet, there was unrelated noise in their audio recording.

Introduction

Many classes were locked down in Hong Kong since the outbreak of COVID-19. The prevalence of dyslexia among children in Hong Kong is 12.6 percent, which is higher than the world's 10 percent. According to the Child Assessment Service of the Department of Health (Child Assessment Service, 2017) and the Education Bureau's student enrolment statistics (Student Enrolment Statistics, 2020), the estimated number of dyslexic students in Hong Kong primary schools is around 41,000. During the class suspension period, the majority of dyslexic students' support has been cancelled outright, especially dyslexia training and assessment (Press, 2020). In the market, there are a variety of tools to provide training to students. Saine et al. (2011) have launched a computer-assisted remedial reading application – GraphoGame in Finland to help Finnish children with inadequate pre-reading skills and those at risk of reading difficulties improve letter knowledge,

CONTACT Fung Ka Yan, kyfungag@connect.ust.hk

reading accuracy, fluency, and spelling. Skiada et al. (2014) have released an English game application known as EasyLexia, to train children diagnosed dyslexic. Over a short period, students demonstrated improvement in their overall performance, indicating the high effectiveness of this application. Yamazoe et al. (2011) have designed a web-based game in Japan to train children to memorize and write Chinese characters. The characters were broken down into stroke units, and students were asked to drag each stroke to compose the characters. Khakhar and Madhvanath (Khakhar et al., 2010) have created a digital tool in India that enables students to practice writing English letters, phonics, and numbers with the assistance of letter sounds. However, dyslexia is a language-based learning disability (Dyslexia Basics, 2020). In Hong Kong, the first language is Chinese. Indeed, local students learn Chinese characters instead of letters. Among the existing training tools, very few were in Chinese contexts.

The evolution of dyslexia aid tools in Hong Kong lags far behind other languages. The insufficient assistance on dyslexic students' learning urged us to develop a digital learning tool targeting primary one to three students, which can be accessed on smartphones or tablets, providing flexibility to a larger extent, favouring the pandemic situation. Our digital learning tool helps dyslexic students overcome their weaknesses in reading, speaking and writing. Indeed, we encourage them to achieve learning autonomy through games effectively. This study intends to find out the preferable game types of dyslexic students and their performance in writing, audio and language games so that the criteria used to determine a student's degree of dyslexia can be more specific.

Literature review

Students can benefit from digital learning as it provides them with ubiquitous communication and learning assistance (Cheon et al., 2012). Students would improve from educational games in the classroom, in which the teaching style is more entertaining than the conventional one (Virvou et al., 2005). Considering the existing training tools for dyslexic students in Hong Kong, a learning support network, Read & Write, provided paper-based and digital-based teaching materials for junior primary school teachers, which digital materials are DVDs and online video guidance (Teacher development, 2015). The materials are created targeting the reading, writing, and speaking skills of students. The Hong Kong Young Women's Christian Association (YWCA) also initiated a program called Infinity HOPE to help dyslexic students (Infinity, 2016). The program offered paper-based teaching materials (Pan et al., 2015) and digital-based game training for students (HOPE, n.d.). The materials covered Chinese vocabulary and sentences to train students' morphological and syntactic sense (HOPE, n.d. & Pan et al., 2015). Starwish Fair was developed to train dyslexic students using a digital game-based method (Starwish Little Prince, 2013). It focused on multisensory motor learning, literacy training, and the logical thinking of students. It also provided audio instructions

in Cantonese, Mandarin, and English. Among the three tools, Read & Write was the only program that appraised students' changes statistically. A three-year longitudinal study of elementary grade students proved that users were positively influenced by the training (Yeung et al., 2013). While Infinity · HOPE showed a rough improvement in its participants (Infinity, 2016) and Starwish Fair did not. Furthermore, none of the tools was able to target dyslexic students' needs comprehensively. The lack of training tools for dyslexic students has long been an obstacle. It is pressing to build a digital tool that involves games targeting all needs dyslexic students may face. This study intends to find out the preferred game types of dyslexic students and their performance in writing, audio and language games so that the criteria used to determine a student's degree of dyslexia can be more specific.

Research approach

In considering the existing tools in Hong Kong, there is a lack of interactive and comprehensive digital learning tools to help dyslexic students at home by using Traditional Chinese and Cantonese. We develop our tool using Unity and the C# language. The tool is simple, with large icons to mark it easy to use by children. We also provide an audio function to facilitate our users understand the questions. This study aimed to find out (1) what kind of games dyslexic students prefer, (2) how is the performance of writing games, (3) language games and (4) audio games when they use digital learning tools at home.

Common tool features

The tool contains a few icons activated during the learning period (Figure 1). All games include a Home Button and an Instruction Button. From the top left part of the tool, the icons are:

- Home Button: Go to the home page
- Instruction Button: Listen to the instruction.

Writing games (Figure 2) also include an Eraser Button, a Submission Button, a Hint Button, and a Re-write Button. From the right side of the tool, the icons are:

- Eraser Button: Remove the last stroke drawn
- Submission Button: Submit the handwriting
- Hint Button: Get hints from writing
- Re-write Button: Remove all strokes drawn

Reading aloud games (Figure 3) include a Recording Button at the bottom of the game page. From the bottom of the tool, the icons are:

- Recording Button 1: Automatically record and stop recording after 30 seconds.
- Recording Button 2: Automatically record after Recording Button 1 stops recording and stops recording after 30 seconds.
- Recording Button 3: Automatically record after Recording Button 2 stops recording and stops recording after 30 seconds.

Game design

In this study, we designed 10 types of games for dyslexic students to learn Chinese at home during the COVID-19 pandemic (Table 1). For language games, there were five questions and one validation question for each game. For writing games, there were five questions for each game. For audio games, there were five questions in the vocabulary reading game and one question in the sentence reading game.

Figure 1

Screen of language games. From the top left part of the tool the common icons are Home Button and Instruction Button.

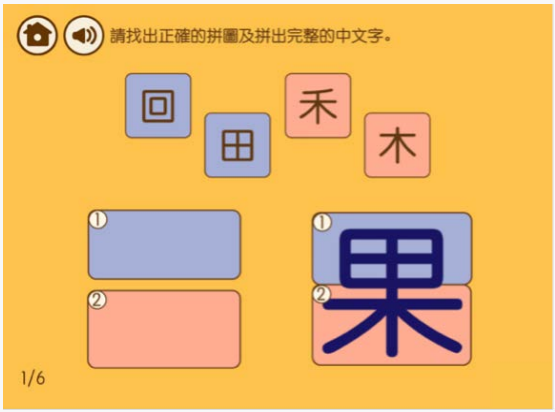


Figure 2

Screen of writing games. From the right side of the tool the common icons are, Eraser Button, Submission Button, Hint Button, Rewrite Button and a signage of stroke number indication.

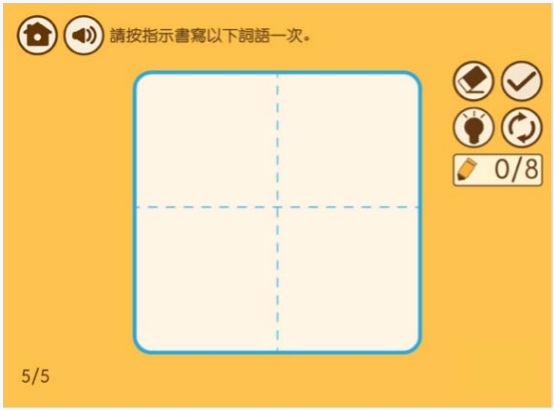


Figure 3

Screen of Reading aloud games. From the bottom of the tool the icons are Recording Button 1, Recording Button 2 and Recording Button 3.]

Game Type 1 to Game Type 3. The Education Bureau suggested that dyslexic students should avoid copying characters repeatedly in training (HKSAR6, 2020). Instead, they should learn from identifying different radicals and components. The former is the root or base form of a Chinese character, whereas the latter is the remaining parts of the character. Therefore, we have created several types of games related to Chinese radicals and components. For instance, Game Type 1 requires students to match images with their respective radicals, Game Type 2 requires students to recognize the correct radicals for the characters, and Game Type 3 asks students to select the suitable radicals and components to form Chinese characters. The Oxford University Press (2019) also created some radical identification exercises for primary one students. According to Small Campus (Hkedcity, 2021), a primary educational website created by Hong Kong Education City Limited, two games are related to Chinese radicals (Read & Write, 2012).

Game Type 4. The Hong Kong Specific Learning Difficulties Research Team (Hong Kong Specific Learning Difficulties Research Team, 2007) emphasized the importance of the order of strokes when writing Chinese characters. Therefore, in Game Type 4, we clarified the stroke order by providing step-by-step guidance for students to follow.

Game Type 5 and Game Type 6. Most Chinese characters are semantic-phonetic structured, containing a semantic radical implicating a meaning and a phonetic radical denoting a sound (Deacon et al., 2016). On the grounds of this structure, Game Type 5 tests students' phonological awareness in differentiating words in written language from spoken language. Since word identification and vocabulary knowledge are related

to morphological formation (McBride et al., 2003), Game Type 6 assesses students' semantic and morphological skills in classifying meaning-related words.

Game Type 7. Dyslexic students are weak in visual and spatial cognition ability (Read & Write, 2012). Controlling writing space could be difficult for them. Unlike the linear structure of alphabetic words, Chinese characters have a square and nonlinear configuration (Tan et al., 2000). So, we created Game Type 7, which provides students with Chinese writing grids for copying to help dyslexic students locate the centre of a Chinese character and manage to write the other components.

Game Type 8. Game Type 8 is related to vocabulary. With references to Oxford University Press (2019), we created vocabulary and image matching games, a game that requires students to write the vocabulary according to the images given. Based on Kavaliauskienė and Darginavičienė's findings (2009), dictation could benefit students' short-term memory. Regarding this advantage, we also designed a dictation based on vocabulary audio recordings. Another two games encourage students to think independently without the assistance of word choices so that we can test their memory performance.

Game Type 9 and Game Type 10. Directional confusion could be a symptom of dyslexia (Plessis, 2021), be it left-right confusion or up-down confusion. Some dyslexic students, also known as dyscalculia, are weak in the number sense (Rees, 2014). Considering these possible causes, we also designed a directional game – Game Type 9, and a vocabulary and digit game – Game Type 10.

Experiment design

Before the start of the games, an instruction video and an instruction guideline are demonstrated to the students and their parents respectively. There were ten games, including writing games, reading aloud games, Chinese radical and component games, Chinese vocabulary and digit games. Students can play the games anytime in any order for four months.

Participants

We recruited 10 students (6 males and 4 females) aged 7 to 9 years old (M= 8.58-year-old, SD= 0.37-year-old), from a local primary school in Hong Kong. The inclusion criteria for students to participate in this study were (1) studying in grade 2 and grade 3; (2) being able to read and write traditional Chinese characters and speak Cantonese; and (3) having no other medical or physical disabilities that might interfere with the

handwriting ability and reading aloud ability. Three of the participants were in grade 2, and 7 in grade 3. Among the participants, 5 were diagnosed with dyslexia (all in grade 3), specifically writing problems, and were pre-screened by teachers. Prior to running the experiment, we obtained informed consent from the student's parents.

Dependent variables

Table 1

Description of Dependent Variables, example 扌丁 *(literally. hit)*

Descriptions	Samples
Disproportionate size among components [43] Students lack the ability to write Chinese characters with appropriate proportioning of components. Example: The right component is too small in size.	
Disproportionate spatial organization [43] The components in a character being too close to one another or scattered beyond the writing grid [43]. Example: The radical and the component are too separated from each other.	
Transposition of radicals or logographemes [39] Radicals and/or components are horizontally or vertically swapped. Example: The radical and the component are switched in position.	
Stroke insertion/ Stroke deletion An extra stroke is inserted to the character or a required stroke is omitted from the character [42]. Example: A stroke in the radical is missing.	
Component insertion/ Component deletion An extra component is inserted to the character or the required component is omitted from the character. Example: The component is missing from the character.	
Erroneous components [39] A wrong component is used to replace the correct one, usually resulting in non-characters, occasionally real characters. Example: A wrong radical is written.	
Spatial layout in a square [40] The written character is inclined to the side, leaving plenty of space in the square box. Example: The character is inclined to the upper left corner of the grid.	

Results

What kind of games do dyslexic students prefer?

From 1st Month to 4th Month, both dyslexic students and non-dyslexic students had high participation rates in the non-writing-non-audio category (Figure4). Among all game types, both dyslexic students and non-dyslexic students preferred Game Type 2 - Radicals and Chinese characters matching (Figure 5).

Figure 4

The numbers of trials of both dyslexic and non-dyslexic students of each category from 1st Month to 4th Month.

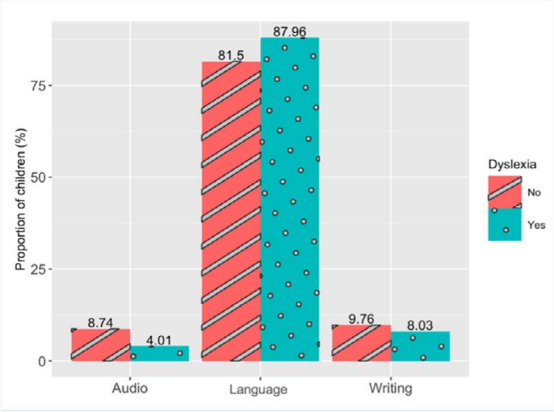
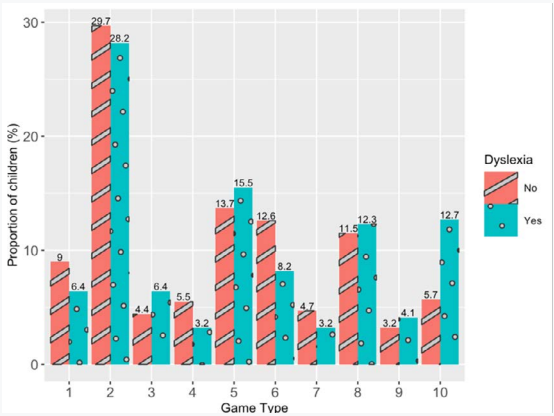


Figure 5

The numbers of trials of both dyslexic and non-dyslexic students of each Game Type from 1st Month to 4th Month



What is the performance in writing games?

Time. We found that one of the main effects of Dyslexia is on average time spent on handwriting. In December 2020, dyslexic students wrote slower than non-dyslexia students. After four-month training, dyslexic students had a significant improvement. They were even faster than non-dyslexic students (Figure 6).

Mean score. We found that the mean score of both dyslexic students and non-dyslexic students were increasing during the four-month training (Figure 7). In December 2020, dyslexic students (M=8.81 marks, SD=2.79 marks) scored higher than non-dyslexia students (M=6.60 marks, SD=3.70 marks). There was a significant difference between the two groups, (p-value <0.05). After four-month training, dyslexic students (M=10.5 marks, SD=0 marks) also scored higher than non-dyslexia students (M=9.23 marks, SD=2.23 marks). The difference between the two groups was not significant, (p-value > 0.43).

After four-month training, we found that both groups had improved in performance. From Table 2, we could see that the improvement rate of non-dyslexic students was slightly greater than dyslexic students. Yet, the performance of dyslexic students was better than non-dyslexic students in the four-month training.

Figure 6

The mean time of handwriting games between dyslexic students and non-dyslexic students from 1st Month to 4th Month

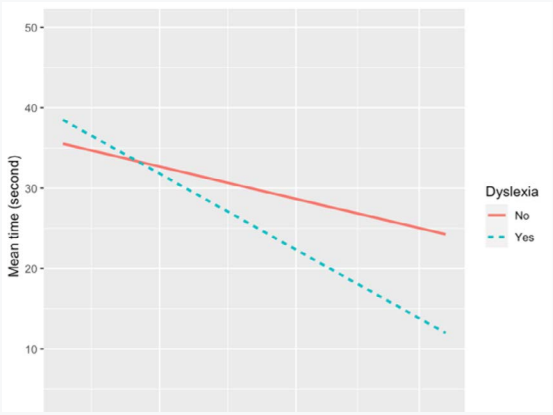
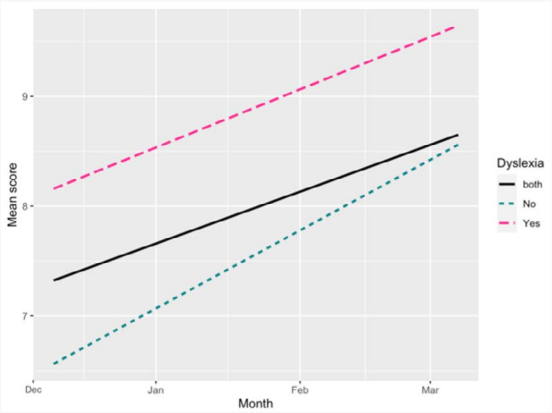


Figure 7

The mean score of handwriting games of dyslexic students, non-dyslexic students and both groups from 1st Month to 4th Month



Transposition of radicals or logographemes. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.548, SD=0.498) to the 4th Month (Mean=0.881, SD=0.328), $p<0.001$. For dyslexic students, there were no significant changes found.

Stroke insertion/ Stroke deletion. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.429, SD=0.465) to the 4th Month (Mean=0.762, SD=0.402), $p<0.001$. For dyslexic students, there were no significant changes found.

Disproportionate spacing among components. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.270, SD=0.322) to the 4th Month (Mean=0.631, SD=0.35), $p<0.001$. For dyslexic students, there were no significant changes found.

Disproportionate size among components. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.270, SD=0.368) to the 4th Month (Mean=0.512, SD=0.39), $p<0.001$. For dyslexic students, there were no significant changes found.

Component insertion/ Component deletion. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.656, SD=0.532) to the 4th Month (Mean=0.869, SD=0.332), $p<0.001$. For dyslexic students, there were no significant changes found.

Table 2

*The performance of handwriting games, including means, standard deviation (S.D.) and p-value. *n = the number of written Chinese characters*

			Transposition of radicals or logograp-hemes	Stroke insertion/ Stroke Deletion	Dispropo-rtionate spacing among components	Dispropo-rtionate size among components	Component insertion/ Component Deletion	Spatial layout in a square	Erroneous compon-ents
Dyslexia	1st Month	Mean	0.881	0.690	0.536	0.560	0.905	0.595	0.869
		S.D.	0.328	0.427	0.338	0.353	0.297	0.317	0.332
		n	42	42	42	42	42	42	42
	4th Month	Mean	1.000	0.750	0.750	0.750	1.000	1.000	1.000
		S.D.	0.000	0.354	0.354	0.354	0.000	0.000	0.000
		n	2	2	2	2	2	2	2
		p-value	0.614	0.848	0.387	0.46	0.656	0.081	0.585
Non-dyslexia	1st Month	Mean	0.548	0.429	0.270	0.270	0.532	0.278	0.508
		S.D.	0.498	0.465	0.322	0.368	0.491	0.333	0.496
		n	63	63	63	63	63	63	63
	4th Month	Mean	0.881	0.762	0.631	0.512	0.869	0.679	0.857
		S.D.	0.328	0.402	0.35	0.39	0.332	0.346	0.337
		n	42	42	42	42	42	42	42
		p-value	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Both group	1st Month	Mean	0.656	0.514	0.362	0.372	0.656	0.39	0.628
		S.D.	0.475	0.469	0.353	0.387	0.47	0.362	0.478
		n	105	105	105	105	105	105	105
	4th Month	Mean	0.830	0.713	0.596	0.489	0.819	0.649	0.809
		S.D.	0.380	0.427	0.371	0.397	0.382	0.375	0.384
		n	44	44	44	44	44	44	44
		p-value	0.028	0.014	0.001	0.086	0.037	0.001	0.024

Spatial layout in a square. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.081, SD=0.278) to the 4th Month (Mean=0.679, SD=0.346), $p<0.001$. For dyslexic students, there were no significant changes found.

Erroneous components. Results from the ANOVA showed that non-dyslexic students, had significant improvement from the 1st Month (Mean=0.508, SD=0.496) to the 4th Month (Mean=0.857, SD=0.337), $p<0.001$. For dyslexic students, there were no significant changes found.

What is the performance in the language games?

By removing the invalid answers, we found that the non-dyslexic students (M = 0.749, SD = 0.296) performed better than dyslexic students (M = 0.636, SD = 0.369) in December (Figure 8). After four-month training, although non-dyslexic students (M = 0.685, SD = 0.309) performed better than dyslexic students (M = 0.633, SD = 0.299), the improvement of dyslexic students was significant (Figure 8). In the first month, the proportion of invalid answers produced by dyslexic students was around 40%, while non-dyslexic students were around 20% (Figure 9). Yet, in the fourth month, the proportion of invalid answers produced by dyslexic students escalated to nearly 70%, while non-dyslexic students were around 25%.

What is the performance in audio games?

Rapid Auto-Naming. From 1st Month to 4th Month, only one dyslexic student and four non-dyslexic students played this game. The dyslexic student recorded three questions and skipped two questions. For non-dyslexic students, they had some problems with their utterances, like pronouncing 祖父 (literally: grandfather) "zou2 fu6" as "zou2 fu4", 依然 (literally: still) "ji1 jin4" as "ji1 ji4", 蛋　　(literally: cake) "daan6 gou1" as "daan6 gung1", 泥土 (literally: soil) "nai4 tou2" as "nei5 tou2", 明白 (literally: understand) "ming4 baak6" as "baak6 ming4" and 練習 (literally: exercise) "lin6 zaap6" as "lim5 zaak6".

Vocabulary-Reading. From 1st Month to 4th Month, only non-dyslexic students played this game. They had common problems in reading 兒童 (literally: children). They would confuse it with 兒子 (literally: son) or 嬰兒 (literally: baby). Besides, they could not pronounce 水果 (literally: fruit) "seoi2 gwo2" correctly either. Some would pronounce it as "thui go2", "seoi2 go2", "deoi6 go2" or "seoi2 go2".

Sentence Reading. From 1st Month to 4th Month, only non-dyslexic students played this game. Among nine audios, six of them are soundless. For the rest of the three, they could only read out a small part of the sentence.

Figure 8

The mean score of the language games of dyslexic students, non-dyslexic students and both groups from 1st Month to 4th Month (Removed the non-valid answer)

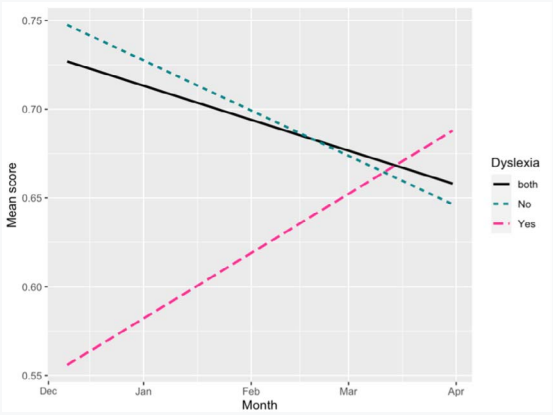
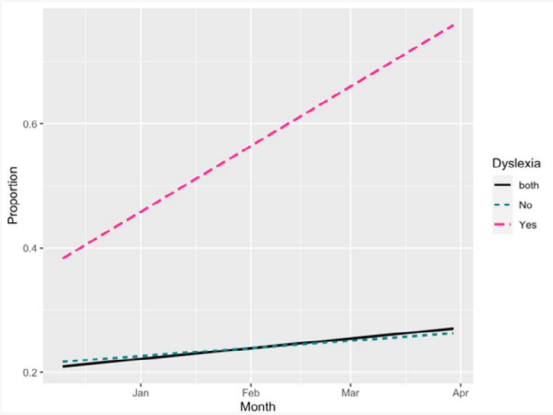


Figure 9

The proportion of non-valid answers in the language games of dyslexic students, non-dyslexic students and both groups from 1st Month to 4th Month



Conclusions and limitations

In this paper, we introduced a digital tool that we designed for both dyslexic and non-dyslexic students when learning Chinese at home during COVID-19 pandemic. In our experiment, we found that dyslexic students were unmotivated after a few months of home-based learning. They evaded from handwriting games and audio games. The main reason we identify for that is the young age of the children and the adaptability of sudden change of learning mode. Besides, the living space in Hong Kong is quite limited, the children may not have a proper learning environment when they learn at home. Indeed, some children may not have a suitable device to support their learning at home. In general, dyslexic students preferred Game Type 2, Game Type 5 and Game Type 10 the most, while non-dyslexic students preferred Game Type 2, Game Type 5 and Game Type 6 the most. Students generally did not take part in the rapid naming game. We found that there was a lot of unrelated noise in the recording. Some students pressed the "recording" button, but they did not say anything. Also, some students would read out the content accompanied by other speakers simultaneously. Furthermore, some students would shout suddenly during recording and the noise would ruin the analysis. Indeed, some students' parents would record by themselves to substitute for their children. In writing games, both groups of students had improved significantly in transposition of radicals or logographemes, stroke insertion, stroke deletion, disproportionate spacing among components, disproportionate size among components, component insertion or component deletion, spatial layout in a square and erroneous component.

Future work

In the future, we hope to design and develop more game types to motivate dyslexic students to learn Chinese at home and help them improve their reading, writing and pronunciation skills. Besides, we will compare the performance of the same games played at home and schools to find out the differences in performance. Indeed, we will also compare the performance of paper-based learning and digital learning. Currently, we only collected and analyzed quantitative data. To improve the quality of data analysis, qualitative data will be collected in the future, such as interviews with students, parents and teachers, and more students will be recruited to conduct the trial to enrich the research contribution.

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