Advances in Educational Technology and Psychology (2021)
Clausius Scientific Press, Canada

DOI: 10.23977/aetp.2021.59002
ISSN 2371-9400 Vol. 5 Num. 9

Evaluation of Different Teaching Strategies in Sight Words Instruction of Chinese Children with Autism: Text-picture Matching, Picture-embedded, and Word Tracing

Zhenzhong Wang*

Department of Language and Humanities Education, Universiti Putra Malaysia, Malaysia

wangzhenzhongfreya@gmail.com

**corresponding author*

Keywords: Autism spectrum disorder, Literacy, Text-picture matching, Picture-embedded, Handwriting

Abstract: This study investigated and compared whether text-picture matching, picture-embedded and word tracing intervention strategies can promote the learning of Chinese characters by Chinese ASD children. The core theory is the effect of picture stimulation and handwriting stimulation on literacy ability. The participants were all 24 children aged 6-12 years in a rehabilitation center in Shanxi Province, China. The children were randomly divided into a treatment group and a control group; the treatment group used these three methods to teach four Chinese characters in turn, and the control group used text-only. A total of three intervention experiments were conducted, and each experimental group used different intervention methods to teach new Chinese characters. The results show that these three intervention strategies all promote the literacy of Chinese children with ASD, but the picture-embedded teaching strategy is not recommended. Due to the short experimental period, future work can continue to study and compare the effectiveness of text-picture matching and word tracing.

1. Introduction

Autism Spectrum Disorder (ASD) is defined as an early-onset neurodevelopmental disorder in which patients have obvious characteristics such as social communication disorders and restricted or repetitive behaviors (American Psychiatric Association, 2013). Statistics from the Centers for Disease Control (CDC 2014) show that 1 in 68 children in the United States is diagnosed with autism spectrum disorder (ASD). Wang et al. (2013) 19 studies from mainland China estimated that the prevalence of autism had reached 30.41 per 10,000 people. It seems that there was an upward trend all over the world over time. Recent theoretical developments have revealed that learning English vocabulary or Chinese characters could be a troublesome preparation for children with autism. Some past researchers have found that the

performance of literacy skills in ASD patients seems to be related to their related language deficits. Among them, their dyslexia is the most serious, mainly at the vocabulary level (Dynia et al., 2014; Nally et al., 2018). According to data from the Basic Longitudinal Study of Special Education (SEELS), students with autism show a lower word recognition rate than the average (SRI 2002). In spite of the fact that Dynia and other researchers (2014) found that children with ASD tend to have similar alphabet knowledge comparable to that of their peers, children with disabilities lag in printing concept knowledge, vocabulary, and phonological awareness and cannot master higher-level processing skills (such as language proficiency and reading comprehension) (Nation et al., 2006). Additionally, the lexicon breadth of Chinese children with high functioning autism in Chinese language learning is essentially littler than that of ordinary children; their understanding of word meaning is additionally weaker than that of normal children (Peng Hui; Zheng Li, 2014). Even though children with autism have numerous challenges in recognizing lexicon, they can still make up for their capacities and increase their knowledge through literacy teaching. Learning through literacy not only can reinforce their mastery of original concepts, but also expand their lexicon through grouping words (Zhang Qin & Zan Fei, 2007). Additionally, in a past EBP investigation of students with ASD, Spector (2010) claimed that the center of reading is words. Failure to recognize words implies that reading cannot continue smoothly. Therefore, in order to improve reading comprehension, educators need to conduct vocabulary teaching and comprehension strategy training to solve their problems in reading comprehension (Roux et al., 2014; Howorth et al., 2016). But for ASD students who have difficulty understanding abstract and auditory concepts, educators can be educating them with sight words. Sight words are words that are recognized immediately (Ehri, 2005). Broun and Oelwein (2007) believe that the sight-word teaching may be a more reasonable beginning point for vocabulary teaching, compared with the phonics-based strategy utilized by ordinary students.

1.1 The Influence of Pictures on Sight Word Acquisiton

A controversial issue is whether pictures are valuable for obtaining sight words. A few researchers argued that simultaneous teaching of the image and text is beneficial to sight words acquisition. A teaching sight words strategy that numerous previous studies had focused on is to pair vocabulary words with corresponding pictures to help children form associations between written words and their meanings (Elliott & Zhang, 1998; Paivio, 1991). Afterward, the research result of Fossett & Mirenda (2006) showed that picture-to-text matching develops sight words more effectively and maintains them for a longer time. They assumed that this method might be valuable for children with low cognitive ability. Although in experiment 2 of Richardson et al. (2016), all three members performed better under text-picture matching conditions during training than under text-only conditions. But they did not strongly support educators use this teaching strategy because the efficiency of this teaching strategy is much lower than the text-only condition. Therefore, they believed that the text-picture matching method uses to teach only a few words, and it can even utilize as a supplement to phonics-based teaching. In addition to text-picture matching, the intervention of picture-embedded words was more successful than words alone within the teaching of sight words for ordinary children. However, Strauber et al. (2020) believed that it might be because the method uses related phrases and actions that help to establish the association between pictures and words and incorporates phonics instructions. Even though several studies had demonstrated that instructing both pictures and text is valuable to the students' learning of sight words, some studies on the effectiveness of this strategy in the last century had found learning sight words together with pictures was often harmful and has no advantage (Singer et al., 1973; Pufpaff et al., 2000). A number of researchers found that these impediments reflected in the fact that pictures

disrupt the learning process by distracting learners from learning the target words (Singer et al., 1973; Didden et al., 2000). Fossett & Mirenda (2006) explained specific reasons for this. If pictures and text were set side by side or even integrated, children might not understand the association between the two. Secondly, Dittlinger and Lerman (2011) prove this point of view. It turns out that placing images next to sight words will cause a blocking effect. However, for Chinese autistic children to memorize Chinese characters, the pictures have played a good impact. Studies have shown that within the process of semantic processing, children with ASD appear obvious advantages in visual graphics coding, and rely more on visual ability, it is easier to learn semantics through pictures than to understand semantics through text alone (CAO Shuqin & FANG Junming, 2010). The different effects of the picture on the acquisition of English vocabulary and Chinese characters may be due to the essential difference between Chinese and English. Common sense seems to dictate that English is a phonogram, and Chinese characters are an ideogram.

1.2 The Influence of Writing on Sight Word Acquisition

Tan et al. (2003) believed that the language expression of the brain is culturally specific. They concluded from the structural diagram analysis of the brain that the temporal-parietal area responsible for reading English is close to the auditory area of the brain, and the middle frontal gyrus responsible for reading Chinese is close to the motor area of the brain. Putting it simply, learning Chinese is dependent on writing, whereas learning English is dependent on listening and reading. Afterward, Tan et al. (2005) further studied a series of Chinese children with dyslexia that writing capacity is more critical than phonological awareness and is the most important indicator of reading capacity. Once again, it demonstrates that Chinese children learn to read by writing Chinese characters repeatedly. Researchers Longcamp et al. (2008) documented the importance of this strategy in helping adults improve their word recognition by memorizing specific movements such as writing. However, Bi et al. (2009) conducted a study on a Chinese brain injury patient (HLD) and raised objections. The study showed that the patient accesses semantics and speech simultaneously in the reading and recognizes the facial features, even though he cannot accurately copy or write. As demonstrated by this result, read does not rely on writing, even in Chinese. Several studies have gradually shown that handwriting can still promote students' literacy and reading in recent years. James & Engelhardt (2012) showed that writing and reading are interrelated processes, including sensorimotor components. Handwriting may help young children's reading acquisition. Ose Askvik et al. (2020) conducted a study on a group of young people and 12-year-old children and showed that cursive script helps the brain to learn and remember. Similarly, handwriting also plays a significant role in Chinese learning. Pinyin typing is harmful to students' literacy abilities, and it will interfere with the ability to read and acquire Chinese characters. However, the ability to write well may enhance a child's ability to read. Reduced handwriting may lead to substantial decreases in children's reading comprehension and writing ability when they lack proficient perceptual-kinesthetic integration ability (Guan et al., 2011; Tan et al., 2012). Writing strengthens the association between orthography and semantics of grown-up Chinese-as-a-foreign-language students (Guan et al., 2015). The same as the past findings, that is, the phonetic knowledge improved after the Pinyin typing practice, and the semantic knowledge improved after the handwriting practice. The investigation of Guan Qun and Zhao Jianrong (2019) also affirmed this view. And the behavioral comes about are consistent with comes about of EEG data. Handwriting exercises can also advance second language perception, even though the impact is not self-evident in children but more self-evident in grown-ups.

1.3 Present Study

As discussed, a controversial issue is whether picture intervention strategies can improve English vocabulary acquisition and whether writing exercises are helpful for Chinese vocabulary learning. Although some researches have demonstrated that picture intervention and writing are more successful in sight-word teaching than the intervention of utilizing words alone, the participants incorporate English-speaking students or students with developmental disabilities or Noonan's Syndrome or ordinary students or adults (Fossett & Mirenda, 2006; Richardson et al., 2016; Strauber et al., 2020; Guan et al., 2015). There are also studies whose samples are too small to prove (Birkan et al., 2007). So far, there is no specific research on the literacy strategy of Chinese children with ASD. In order to bridge this gap, this study investigates effective literacy teaching interventions for Chinese children with autism particularly and contains a more sample than all other known reports in this field, which makes the result more representative and universal. The research aimed to explore the teaching strategies of sight words suitable for Chinese ASD students, compare the effectiveness of pictures and exercises for literacy (text-picture matching, picture-embedded, and word tracing strategies), and find out the most suitable ASD Children's teaching methods and targeted teaching to cultivate their better literacy skills and adapt to social life. To this end, this study aims to answer the following research questions: (1) In a longitudinal comparison, are these three teaching strategies useful for students with autism? Based on previous literature, we hypothesize that all three strategies will speed up the acquisition of Chinese characters and vocabulary by autistic students. (2) In a horizontal comparison, which strategy is more effective for autistic students who have received the intervention of these three teaching strategies? For the second research question, we hypothesize that students who have received three different teaching interventions are more sensitive to word tracing teaching strategy and easier to acquire Chinese characters.

2. Method

2.1 Participants and Settings

All potential participants were recruited from a rehabilitation center in Shanxi Province，China through recommendations from educators and social workers. A total of 24 students were recruited, including 9 girls and 15 boys (mean age = 8.58 years). Participants' inclusion criteria are as follows: (1) 6-12 years old; (2) Clinically diagnosed as ASD level 2; (3) encountered learning difficulties reported by parents during the admission interview; (4) Demonstrate a strong motivation to participate in the intervention; (5) No hearing, vision, or physical impairment that may hinder participation in the activity has been diagnosed; (6) No confirmed history of major mental illness or other confirmed diseases that may affect participation in the intervention. Prior to the screening process, written and oral consents from all parents and the Head of Rehabilitation Center have been obtained.

2.2 Materials and Equipment

All teaching materials were presented separately in the middle of 148 x 210mm (A5) white plastic cards. All of the characters were printed in black KaiTi font with a size of 250pt. The picture used in the text-picture matching was a physical picture with a size of 600mm×600mm and was located in the middle of the plastic card. Picture-embedded characters must not only fit the shape of the Chinese characters but

also provide materials for establishing a connection between the Chinese characters and their meanings. For example, in the Chinese character Mi, Mi is stylized into a lot of rice, and the image of rice is embedded in the glyph of the Chinese character. In word tracing, the horizontal A4 size paper is divided into two parts, a total of two rows of square grids with red borders. The first row provides students with the stroke order of the characters, and the second row is used for students to trace and write. The light red characters in the first three squares are designed to allow students to trace the strokes of the characters, and the last four are blank squares for students to write independently. In the actual experiment, the Chinese characters taught by each teaching strategy are new characters that children do not recognize.

2.3 Experimental Procedure

The research method of this study is a randomized controlled trial. The children were randomly assigned to the experimental group (n = 12) and the control group (n = 12). Before the intervention teaching started, in order to check whether the groups match on various baseline indicators and to ensure that the Chinese characters taught are new words that the students did not recognize, a baseline measure was performed. A survey of demographic characteristics was distributed to the parents of the students participating in the study, and the teaching content was determined through pre-tests. In the intervention teaching experiment, the control group studied under the condition of only text, while the treatment group used three intervention teaching strategies to study separately. The cycle of each intervention teaching strategy was 7 days, and the Chinese characters taught in each cycle were different. Under the premise that the control group and the experimental group remained unchanged, the experiment group adopted the teaching strategy of text-picture matching in the first cycle. In the second cycle, students in the experimental group learned under the condition of picture embedding, and they adopted the intervention method of word tracing in the last cycle. The experimental process of each cycle includes three stages: acquisition period, immediate post-test, and retention test. In the intervention phase, every student participated in a 20-minute one-to-one intervention course in turns and conducted the same teaching course for two consecutive days. Under each experimental condition, children were exposed to vocabulary in random order every day. After the second day of the course, a post-test was performed immediately and the number of correct answers was recorded. A retention test was conducted on the 4th and 7th days, and the number of correct answers was recorded to measure the retention rate of the words taught. The experiment schedule is represented in Table 1.

Table 1: Experiment schedule for participants in the study

	First Cycle		Second Cycle		Third Cycle	
	Text-picture Matching	Text-only	Picture-embedded	Text-only	Word Tracing	Text-only
Day 1	20-minute intervention course					
Day 2	Repeat Day 1 procedure and followed by Immediate post-test					
Day 4	Retention test					
Day 7	Retention test					

2.3.1 Baseline Measures

A survey of demographic characteristics asked questions about the age and gender of the

students, the background of the caregivers, the parent’s education level, the nature of the child’s schooling, and interest/hobby areas (animals, food, occupations, and daily necessities). An average selection of Chinese characters in different fields from the word list of Shenghuo Yuwen (Zhang Lianchi, 2018), and continued the word selection process. In the word selection process, the text-only form of each character in the word list is shown to 24 children one by one on the flashcard. The children were asked to take the pre-test individually and read each character as follows: "What is this character? Please read it to me. It doesn't matter if you don't know the word; just say,' I don't know." The child's answer to each character will be recorded. After the pre-test, the researcher selected 12 unknown Chinese characters and grouped them into three-word sets, and used them in three experimental cycles.

2.3.2 Text-Only

In each intervention experiment of pure text stimulation, the researcher held up a laminated paper containing only text for teaching. First, the researcher told the participants the pronunciation of Chinese characters and asked them to read them together. According to the unresponsive or incorrect responses, the researcher used the least to the most intrusive prompting level (for example, /m/, /mi/) for teaching until the participants had the correct response, that is, the correct pronunciation, they will receive verbal praise from the researcher and a small snack. Afterward, the researcher explained each Chinese character meaning to deepen students' memory and understanding. After the teaching, the researcher conducted training to strengthen the memory of the students. First, the researcher quickly drew out a word card, and the students needed to read it rapidly. After that, the researchers arranged all the learned word cards randomly on the table. They spoke one of the four words and asked the learner to pate the word with their hands. After completing the two training sessions, the researcher proceeded to the next stage, randomly pointing a character card and asking the students to read the character. Each training session was repeated twice before jumping to the next one. During training, students can get a positive feedback if they answer correctly. In the case of an incorrect answer, the child needed to try again until the answer was correct.

2.3.3 Text-Picture Matching

Under the condition of text-picture matching, participants rarely need echo prompts. The researcher first showed the students only the physical picture and told them what it was. In the next step, the researcher only showed them the Chinese characters corresponding to this picture and taught them the pronunciation. Once the participants pronounced correctly, the researcher would give them positive feedback (verbal praise or snacks). Finally, the physical picture and its Chinese characters were put together on the table for teaching to strengthen the memory. After the teaching, the researcher quickly drew out a physical picture card of a character, and the students needed to say the relevant word rapidly. Then, the researchers drew out the card of this character so that the students could read it immediately. The next word training could only be carried out after the student has successfully completed it. All the words need to be practiced by participants twice. After that, all physical picture cards and word cards were placed randomly on the table in a 2×4 array. After that, the students should put the word cards and physical picture cards together with one by one. The word matching game would be played by participants twice, and the order of the upper physical picture card and the lower word card is random.

2.3.4 Picture-Embedded

In the picture-embedded character condition, after the teacher presents the card, the teacher speaks the Chinese characters and asks the child to repeat the words. After presenting the Chinese characters, the teacher introduced phrases and explanations related to the embedded pictures (see the picture-embedded character "MI" The four dots look like grains of rice) and showed the students the picture-embedded character. The teacher showed the Chinese character card with the picture-embedded character card to the students and asked them to repeat the pronunciation of Chinese characters. If students could read correctly, they would get rewards. During the training, the teacher held up a picture-embedded card to let the students find the correct Chinese characters from the four-character cards, which had been turned to the back and presented on the table by researchers in advance. In the finding process, the children need to turn the character card to the front for recognition. If the children think that it is not the Chinese character of the picture-embedded card, they will turn to the back. If they thought it was, they would turn to the front and give it to the teacher. The entire training was repeated twice by researchers to strengthen the student's memory.

2.3.5 Word Tracing

In the word tracing method, the teacher showed the students the word tracing card in order for them to grasp the pronunciation and order of strokes of this Chinese character. The teacher wrote in the sequence of strokes on the card with his fingers and allowed students to observe carefully. After that, students have to use their fingers to write Chinese characters on their word tracing card in order of strokes and read as they write. In the next step, the teacher and the student hold the same watercolor pen and write Chinese characters on the card together. After the students are familiar, the students write this Chinese character twice and three times independently. After the teaching, the researcher instructed the children to walk along with the red Chinese characters' strokes pasted on the floor as walking and pronouncing the characters to strengthen the memory. They returned to their seats after walking. The researcher showed a Chinese character to the students and asked them to use sticks of different lengths to decorate the Chinese character according to the shape of the Chinese character while pronounced it correctly to strengthen the students' memory of the characters' appearance.

2.3.6 Immediate Post-Test and Retention Test

At the end of the second day of the research cycle, the researcher conducted an immediate post-test with the students. The retention test was performed on the 4th and 7th days. The independent correct response during the Immediate post-test and Retention test was defined as the child uttering written Chinese characters within 5 seconds of the researcher asking "What word?" without any prompts. During the test, the researchers showed each Chinese character to students from the experimental group and the control group at least three times to ensure that students are fully aware of this Chinese character. The order of presentation of words on each test day is random. If the participant made an incorrect reaction in two consecutive shows, it would be considered that the Chinese character is unknown. The student's answers to each word were recorded on the retention tests' record sheet. If a student missed the reserved test day, the researcher would arrange for the absent student to take the test separately at other times.

3. Result

3.1 Baseline

Although the answers collected in the census are classified, we convert them into binary variables for the convenience of analysis. The binary files used are: whether the child is a male, whether their caregiver is one of the parents, whether their mother has a bachelor degree, whether their father has at least a bachelor degree, whether the child is a boarder, whether the child is interested in the card theme as animals, food, occupation, and daily necessities. In addition to these, the data on their age was included as a baseline measurement. Table 2 shows the demographic data of children and their family backgrounds. The results indicate that no significant differences exist between the groups for any baseline measurements collected ($P > 0.05$, two-sided Fisher's exact test). Based on this result, the experimental and control group had basically the same self-conditions, and their family backgrounds were the same. The next step of experimental intervention can be undertaken since there is no difference between them.

Table 2: Demographic characteristic of the treatment and control groups at Baseline

	Mean in TG	Mean in CG	Mean Difference	SE	t(22)	p
Age	8.75	8.42	0.33	0.85	0.38	0.701
Male (y/n)	0.58	0.67	-0.08	0.206	-0.40	0.689
Caregiver (y/n)	0.67	0.58	-0.08	0.206	0.40	0.689
Boarder (y/n)	0.58	0.42	0.16	0.210	0.79	0.436
Mother is bachelor	0.50	0.58	-0.08	0.212	-0.39	0.698
Father is bachelor	0.67	0.58	0.08	0.206	0.40	0.689
Animal	0.83	0.83	0.00	0.159	0.00	1.000
Food	0.67	0.75	-0.08	0.193	-0.43	0.670
Occupation	0.58	0.58	0.00	0.210	0.00	1.000
Daily necessity	0.83	0.83	0.00	0.159	0.00	1.000

3.2 Comparision of Experimental Group and Control Under Text-Picture Matching Strategy

The data of treatment and control groups used two-tailed independent samples t-tests to compare at every time point. The mean, standard deviation, and significance of the differences between groups at each time point are shown in Table 3. In the Immediate post-test and Retention test day 4, the average numbers of text-picture matching conditions were 0.67 and 0.83 words higher than the text-only condition, and differences were significant at $p<0.05$. The score of the text-picture matching condition in Retention test day 7 is 1.25 words higher than that of the text-only, and the difference is significant at $p<0.01$. This result supports the hypothesis that there is a difference significant between using a text-picture matching strategy and a text-only strategy for children with ASD to learn new Chinese characters. There was no attrition from either group in this 7-day cycle. The difference between the conditions in the Retention test was more major than in the Immediate post-test, mainly because the score of the control group drops faster than that of the treatment group. The outcome proved that after the intervention of the text-picture matching, the improvement of the literacy ability of the students in the experimental group was significantly more special than that of the control group. It indicated that the text-picture matching could promote the learning of sight words of Chinese ASD children.

Table 3: t-results of comparing treatment group (text-picture matching) and control group (text-only) on Immediate post-test, Retention test day 4, and Retention test day 7

	Treatment group (n=12)		Control group (n=12)			
	Mean	SD	Mean	SD	t(22)	p
immediate post-test	3.25	0.75	2.58	0.66	2.29	0.032
Retention test day 4	2.83	1.11	2.00	0.73	2.15	0.042
Retention test day 7	2.83	1.11	1.58	0.90	3.02	0.006

3.3 Comparision of Experimental Group and Control under Picture-Embedded Strategy

Table 4 lists the average, standard deviation, and p-value of the original scores obtained in the second cycle of the treatment group and the control group within three days. The treatment group was tested after the picture-embedded intervention, while the control group was tested under text-only conditions. Independent sample t-test did not show significant differences between using picture-embedded strategy to teach and using text-only in immediate post-test and Retention test day 4 (both $p > 0.05$). While in the last Retention test day 7, they had a significant difference($p < 0.05$). According to data records, during the immediate post-test period, the average score of the students who received the picture-embedded intervention was 2.92 words (SD=0.90), and the control group was 2.75 words (SD=0.62). The average Chinese characters acquired in the control group decreased gradually with about 0.4 words on Day 4 and Day 7, with 2.33 (SD=0.77) and 1.92 (SD=0.79), respectively. However, the decline in the experimental group was slow, respectively 2.92 (SD=1.08) and 2.75 (SD=1.05). Although the retention test showed slight significance between the experimental and the control groups (p=0.040) on the Retention test day 7, there was no significance between the immediate post-test and the Retention test day 4. It showed that the picture-embedded strategy is ineffective for ASD students, and the promotion effect is not high.

Table 4: t-results of comparing treatment group (picture-embedded) and control group (text-only) on Immediate post-test, Retention test day 4, and Retention test day 7

	Treatment group (n=12)		Control group (n=12)			
	Mean	SD	Mean	SD	t (22)	p
immediate post-test	2.92	0.90	2.75	0.62	0.528	0.603
Retention test day 4	2.92	1.08	2.33	0.77	1.514	0.144
Retention test day 7	2.75	1.05	1.92	0.79	2.187	0.040

3.4 Comparision of Experimental Group and Control under Word Tracing Strategy

Table 5 shows the average, standard deviation, and p-value of the original data obtained in the treatment and the control groups under the word tracing condition within three days. According to Table 5, ASD students in the immediate post-test experimental group and the control group obtained the highest average Chinese characters at 3.08 (SD=0.79) and 2.33 (SD=0.88), respectively. The average scores of the experimental and the control groups were 2.75 (SD=1.05) and 1.75 (SD=0.75), respectively. Their value dropped to 2.42 (SD=0.90) and 1.58 (SD=0.79) on the last day. At any point in time, students in the experimental group remembered more Chinese characters on average than those in the control group. This output showed word tracing method is statistically significant in the immediate post-test and retention test because their p-value (0.040, 0.014, and 0.025) were less than the significant level of 0.05. The result showed that word tracing is very effective in promoting the ability to learn Chinese characters. In the three days test, the effects were most noticeable on retention day 4, the second on retention day 7, and the last on immediate post-test.

Table 5 t-results of comparing treatment group (word tracing) and control group (text-only) on immediate post-test, Retention test day 4, and Retention test day 7

	Treatment group (n=12)		Control group (n=12)			
	Mean	SD	Mean	SD	t(22)	p
immediate post-test	3.08	0.79	2.33	0.88	2.18	0.040
Retention test day 4	2.75	1.05	1.75	0.75	2.67	0.014
Retention test day 7	2.42	0.90	1.58	0.79	2.40	0.025

3.5 Comparision of Experimental Groups under three Strategies

Through the above experimental results, these three intervention methods all had different promoting effects on the literacy ability of Chinese children with ASD. In order to further understand which of these three methods is the most effective for students, the data of the three experimental groups were examined by ANOVA test. Table 6 summarizes the range of parameters used in the three experimental groups under the intervention of different teaching strategies. The p values under immediate post-test, retention test day 4, and retention test day 7 are 0.612, 0.932, and 0.581, respectively, which are all greater than 0.05. The results indicated that no matter in the immediate post-test, retention test day 4, and retention test day 7, no apparent differences exist in utilizing three different methods for children with ASD. Therefore, the effect of the intervention for Chinese children with ASD is the same regardless of whether text-picture, picture-embedded or word tracing strategies.

Table 6 Results of ANOVA analysis on the mean differences between three treatment groups

	Picture-text matching (n=12)		Picture-embedded (n=12)		Word tracing (n=12)		Between Groups			Within Groups				
	Mean	SD	Mean	SD	Mean	SD	Sum of Squares	df	Mean Square	Sum of Squares	df	Mean Square	F	p
immediate post-test	3.25	0.75	2.92	0.90	3.08	0.79	0.66	2	0.33	22.08	33	0.66	0.49	0.612
Retention test day 4	2.83	1.11	2.92	1.08	2.75	1.05	0.16	2	0.08	38.83	33	1.17	0.07	0.932
Retention test day 7	2.83	1.11	2.75	1.05	2.42	0.90	1.16	2	0.58	34.83	33	1.05	0.55	0.581

4. Discussion

From the data analysis point of view, the intervention methods of text-picture matching, picture-embedded, and word tracing promoted the ability of Chinese ASD children to learn Chinese characters. Specifically, it could be seen from Table 2 that there was no significant difference in the personal information background of the experimental group and the control group, which ensured the feasibility of the experiment. It could be seen from Table 3 that, on retention day 7, the difference between the text-picture matching strategy and the text-only strategy was very significant, which is 0.006 ($p<0.01$). However, according to the analysis of Table 4, the picture-embedded and the text-only strategy as experimental variables had no significant difference ($p>0.05$) in the immediate post-test and the Retention test day 4, except for the retention day 7 ($p=0.040$). In Table 5, there were also significant differences between the word tracing intervention method and the text-only intervention method in the three-day test phase. Among them, the difference between the

two was the most significant in the intention day 4. The results proved that word tracing promotes the literacy of Chinese children with ASD. As shown in Table 6, there is no significant difference between text-picture matching, picture-embedded, and word tracing. In other words, the effects of these three intervention strategies on Chinese children with ASD are essentially the same. We have reported here three intervention methods for Chinese ASD children learning Chinese characters. The result shows that it is basically consistent with hypothesis 1 that is all teaching strategies are more effective than plain text teaching, except for the picture-embedded method, which is slightly inadequate. However, its conclusion is inconsistent with Hypothesis 2, and the effects of these three methods on students are similar. The experiment provides new insight into the relationship between using pictures and handwriting to intervention. Specifically, using text-picture matching to teach Chinese ASD students Chinese characters is very effective. This result replicates prior research showing that the text-picture matching strategy is better than text-only and supports this discovery (Fossett & Mirenda, 2006; Richardson et al., 2016). In the actual intervention in teaching, we found that some students who would answer incorrectly did not even know the things in the physical map cards before, and they may not have relevant known knowledge. Due to the lack of background knowledge, it is more difficult for students to associate the physical picture card with the corresponding Chinese characters. In subsequent studies, it can be added to have the background knowledge to confirm this hypothesis. Except that text-picture matching is effective for Chinese children with ASD, the picture-embedded method is ineffective. It only showed a slight difference in the retention test on the last day. Thus, we do not recommend using this strategy in actual teaching. The study of Strauber et al. (2020) has proven that picture embedded method is more effective than the text-only method in teaching visual words for ordinary children. However, this teaching method does not apply to children with ASD. The reason is that pictures interfere with the acquisition of sight word reading when they are integrated with text (Didden et al., 2000; Singer et al., 1973). Finally, the results of this study further verify the importance of handwriting to the reading development of Chinese children (Tan et al., 2005; James & Engelhardt, 2012), and extend this conclusion to the children with ASD Literacy. Although there is not much difference between these three intervention strategies, according to previous studies, handwriting requires long-term training to form muscle memory (Smits, 2021). Therefore, one of the reasons for the lack of significant differences between the three may be that the intervention period is not long enough. One feature that distinguishes this study from previous studies most clearly is that we integrated a variety of literacy teaching methods in this paper and specifically pointed out the impact of pictures and handwriting exercises on literacy. At the same time, this research aimed at the Chinese character learning ability of Chinese children with ASD. It is rare in many previous studies.

This study concluded that the matching of pictures and texts and handwriting could promote students' literacy development. Consequently, this paper suggests that educators use text-picture matching and word tracing methods in order to enable students with Autism Spectrum Disorders to learn Chinese characters, combine those methods to engage more senses in learning, and utilize picture stimulation or hand muscle memory to stimulate learning. Despite the efforts of this research, some shortcomings remain. First, the sample size is too small to generalize the results of this study, as only 24 Chinese students with ASD aged 6 to 12 were selected randomly for randomized controlled trials. In addition, in this study, students of different ages may have different levels of development, and there may also be some differences in literacy skills, which may affect the effectiveness of the intervention. Moreover, all the selected students come from the same rehabilitation center. The conclusion may be affected by the degree of rehabilitation in the center. This conclusion could be supported further by increasing the sample size in future studies and

examining the effectiveness of these three approaches for different ages, rehabilitation centers, or schools students' literacy abilities. In addition, each intervention method in this study only lasted seven days during the entire experimental period, which does not fully guarantee that students have formed long-term memory. The trial period can be increased in subsequent studies to ensure that the conclusions are applicable. We observed in this preliminary study that these factors are effective in teaching Chinese characters compared to the textual approach alone. Subsequent research needs to specify the participants and increase the sample size and intervention period. Through further study and comparison, we could understand more clearly the continuity and feasibility of text-picture matching and handwriting. Tactile perception is a benefit for stimulating the senses, for recognizing Chinese characters by detecting rough or prominent areas of the passage. Future research can focus on this type of approach to teaching. All in all, we hope that this study can serve as a starting point for future exploration of effective intervention strategies for the literacy of children with ASD.

References

[1] American Psychiatric Association. (2013). Diagnostic and Statistical Manual of Mental Disorders, 5th Edition: DSM-5 (5th ed.). American Psychiatric Publishing.

[2] Bi, Y., Han, Z., & Zhang, Y. (2009). Reading does not depend on writing, even in Chinese. Neuropsychologia, 47(4), 1193–1199. https://doi.org/10.1016/j.neuropsychologia.2008.11.006

[3] Broun, L. T., & Oelwein, P. (2007). Literacy development for students with special learning needs: A strength-based approach. Port Chester, NY: National Professional Resources, Inc. Published.

[4] Birkan, B., McClannahan, L. E., & Krantz, P. J. (2007). Effects of superimposition and background fading on the sight-word reading of a boy with autism. Research in Autism Spectrum Disorders, 1(2), 117–125. https://doi.org/10.1016/j.rasd.2006.08.003

[5] CAOShuqin, & FANGJunming. (2010). Zibizhengertong Hanyucihui Yuyijiagonghe Tupianyuyijiagongde Shiyanyanjiu [An Experimental Research on the Semantic Processing of Chinese Vocabulary and Picture in Children with Autism]. Zhongteshujiaoyu

[6] Center for Disease Control. (2014). Data & Statistics. Available from http://www.cdc.gov/ncbddd/autism/data.html.

[7] Davidson, M. M., & Ellis Weismer, S. (2013). Characterization and Prediction of Early Reading Abilities in Children on the Autism Spectrum. Journal of Autism and Developmental Disorders, 44(4), 828–845. https://doi.org/10.1007/s10803-013-1936-2

[8] Didden, R., Prinsen, H., & Sigafoos, J. (2000). THE BLOCKING EFFECT OF PICTORIAL PROMPTS ON SIGHT-WORD READING. Journal of Applied Behavior Analysis, 33(3), 317–320. https://doi.org/10.1901/jaba.2000.33-317

[9] Dittlinger, L. H., & Lerman, D. C. (2011). FURTHER ANALYSIS OF PICTURE INTERFERENCE WHEN TEACHING WORD RECOGNITION TO CHILDREN WITH AUTISM. Journal of Applied Behavior Analysis, 44(2), 341–349. https://doi.org/10.1901/jaba.2011.44-341

[10] Dynia, J. M., Lawton, K., Logan, J. A. R., & Justice, L. M. (2014). Comparing Emergent-Literacy Skills and Home-Literacy Environment of Children With Autism and Their Peers. Topics in Early Childhood Special Education, 34(3), 142–153. https://doi.org/10.1177/0271121414536784

[11] Ehri, L. C. (2005). Learning to Read Words: Theory, Findings, and Issues. Scientific Studies of Reading, 9(2), 167–188. https://doi.org/10.1207/s1532799xssr0902_4

[12] FOSSETT, B., & MIRENDA, P. (2006). Sight word reading in children with developmental disabilities: A comparison of paired associate and picture-to-text matching instruction ☆. Research in Developmental Disabilities, 27(4), 411–429. https://doi.org/10.1016/j.ridd.2005.05.006

[13] Guan, C. Q., Harris, L. N., Meng, W., & Perfetti, C. A. (2015). Erratum to: Writing quality predicts Chinese learning. Reading and Writing, 28(6), 915. https://doi.org/10.1007/s11145-015-9563-2

[14] Guan, C. Q., Liu, Y., Chan, D. H. L., Ye, F., & Perfetti, C. A. (2011). Writing strengthens orthography and alphabetic-coding strengthens phonology in learning to read Chinese. Journal of Educational Psychology, 103(3), 509–522. https://doi.org/10.1037/a0023730

[15] Guan Qun & Zhao Jianrong. (2019). Shouxieyundongdui Zhongyinwenzi Ganzhishenjingzuoyongde Shizhengyanjiu [An Empirical Study on the Effect of Handwriting Exercise on the Perceptual Nerve of Chinese and English Characters]. Jiefangwaiguoyuxueyuan Xuebao

[16] Howorth, S., Lopata, C., Thomeer, M., & Rodgers, J. (2016). Effects of the TWA strategy on expository reading comprehension of students with autism. British Journal of Special Education, 43(1), 39–59. https://doi.org/10.1111/1467-8578.12122

[17] James, K. H., & Engelhardt, L. (2012). The effects of handwriting experience on functional brain development in pre-literate children. Trends in Neuroscience and Education, 1(1), 32–42. https://doi.org/10.1016/j.tine.2012.08.001

[18] Longcamp, M., Boucard, C., Gilhodes, J. C., Anton, J. L., Roth, M., Nazarian, B., & Velay, J. L. (2008). Learning through Hand- or Typewriting Influences Visual Recognition of New Graphic Shapes: Behavioral and Functional Imaging Evidence. Journal of Cognitive Neuroscience, 20(5), 802–815. https://doi.org/10.1162/jocn.2008.20504

[19] Nally, A., Healy, O., Holloway, J., & Lydon, H. (2018). An analysis of reading abilities in children with autism spectrum disorders. Research in Autism Spectrum Disorders, 47, 14–25. https://doi.org/10.1016/j.rasd.2017.12.002

[20] Nation, K., Clarke, P., Wright, B., & Williams, C. (2006). Patterns of Reading Ability in Children with Autism Spectrum Disorder. Journal of Autism and Developmental Disorders, 36(7), 911–919. https://doi.org/10.1007/s10803-006-0130-1

[21] Ose Askvik, E., van der Weel, F. R. R., & van der Meer, A. L. H. (2020). The Importance of Cursive Handwriting Over Typewriting for Learning in the Classroom: A High-Density EEG Study of 12-Year-Old Children and Young Adults. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.01810

[22]Paivio, A. (1991). Dual coding theory: Retrospect and current status. Canadian Journal of Psychology/Revue Canadienne de Psychologie, 45(3), 255–287. https://doi.org/10.1037/h0084295

[23] Peng Hui & Zheng Li. (2014). 5~6sui Gaogongnengzibizhengertonghe Putongertong Cihuishuiping Bijiaoyanjiu [A comparative study on the vocabulary level of 5-6 years old children with high functioning autism and ordinary children]. Youer Jiaoyu

[24] Richardson, A. R., Lerman, D. C., Nissen, M. A., Luck, K. M., Neal, A. E., Bao, S., & Tsami, L. (2016). Can pictures promote the acquisition of sight-word reading? An evaluation of two potential instructional strategies. Journal of Applied Behavior Analysis, 50(1), 67–86. https://doi.org/10.1002/jaba.354

[25] Roux, C., Dion, E., Barrette, A., Dupéré, V., & Fuchs, D. (2014). Efficacy of an Intervention to Enhance Reading Comprehension of Students With High-Functioning Autism Spectrum

Disorder. Remedial and Special Education, 36(3), 131–142. https://doi.org/10.1177/0741932514533998

[26] Singer, H., Samuels, S. J., & Spiroff, J. (1973). The Effect of Pictures and Contextual Conditions on Learning Responses to Printed Words. Reading Research Quarterly, 9(4), 555. https://doi.org/10.2307/747002

[27] Smits, S. (2021, May 5). The Role of Muscle Memory when Learning to Write. Morrells Handwriting. https://morrellshandwriting.co.uk/blog/muscle-memory/

[28] Spector, J. E. (2010). Sight Word Instruction for Students with Autism: An Evaluation of the Evidence Base. Journal of Autism and Developmental Disorders, 41(10), 1411–1422. https://doi.org/10.1007/s10803-010-1165-x

[29] SRI International. (2002). SEELS data tables. Retrieved from http://www.seels.net/search/datatableOverview.htm.

[30] Strauber, C. B., Sorcar, P., Howlett, C., & Goldman, S. (2020). Using a picture-embedded method to support acquisition of sight words. Learning and Instruction, 65, 101248. https://doi.org/10.1016/j.learninstruc.2019.101248

[31] Tan, L. H., Spinks, J. A., Eden, G. F., Perfetti, C. A., & Siok, W. T. (2005). Reading depends on writing, in Chinese. Proceedings of the National Academy of Sciences, 102(24), 8781–8785. https://doi.org/10.1073/pnas.0503523102

[32] Tan, L. H., Spinks, J. A., Feng, C. M., Siok, W. T., Perfetti, C. A., Xiong, J., Fox, P. T., & Gao, J. H. (2003). Neural systems of second language reading are shaped by native language. Human Brain Mapping, 18(3), 158–166. https://doi.org/10.1002/hbm.10089

[33] Tan, L. H., Xu, M., Chang, C. Q., & Siok, W. T. (2012). China's language input system in the digital age affects children's reading development. Proceedings of the National Academy of Sciences, 110(3), 1119–1123. https://doi.org/10.1073/pnas.1213586110

[34] Wan, Y., Hu, Q., Li, T., Jiang, L., Du, Y., Feng, L., Wong, J. C., & Li, C. (2013). Prevalence of autism spectrum disorders among children in China: a systematic review. Shanghai archives of psychiatry, 25(2), 70–80. https://doi.org/10.3969/j.issn.1002-0829.2013.02.003

[35] Zhang Lianchi. (2018). Shenghuo Yuwen [Life Language]. Huadong Shifan Daxue chubanshe

[36] ZhangQ, & ZanF. (2007). Zibizhengertong Yuyannenglixunliande Tezhengfenxi [Analysis of the characteristics of language training for children with autism]. Zhong zuzhigangchengyanjiu