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REVIEW PAPER

A Systematic Review of Picture Exchange Communication System Interventions for Children and Adolescents on the Autism Spectrum in Mainland China

Yan Li[1] · Gabrielle T. Lee[2] · Yan Qi[3] · Sheng Xu[1]

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Abstract
The picture exchange communication system (PECS) is an evidence-based intervention used to improve communication for people on the autism spectrum. Little is known, however, about the extent to which PECS is currently used with Chinese-speaking persons. Our systematic review identified 13 single-case design studies reporting on PECS interventions with a total of 22 participants. The results indicated that PECS increased non-vocal communication behavior for 19 participants, increased speech for six participants, and decreased problem behavior for five participants. Five studies reported social validity, three studies programmed for generalization, and nine studies reported maintenance effects. According to Reichow's (2011) evaluation standards, thirteen studies met only weak criteria indicating that they did not provide good evidence for the effectiveness of PECS in Chinese-speaking persons on the autism spectrum. Implications for future research and practice are discussed.

Keywords Autism spectrum · Communication · Picture exchange communication system · China

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by impairment of social communication and restricted repetitive behavior (American Psychiatric Association, 2013). People on the autism spectrum typically have difficulties in social communication and do not develop eye contact or gestural or other non-vocal means to communicate or to initiate or respond to social interactions (American Psychiatric Association, 2013). Approximately 25–30% of children on the autism spectrum are classified as non-vocal or minimally vocal; that is, they produce no words or a few words but not sentences (Anderson et al., 2007; Norrelgen et al., 2015). Deficiencies in communication abilities are correlated with problem behavior (Helland et al., 2014), poor academic performance (Miller, et al., 2017), and difficulties forming relationships with others (Friedman et al., 2019). It is estimated that about 13 million people on the autism spectrum live in Mainland China (Zhou et al., 2020). China's 14th Five-Year National Health Plan includes an emphasis on interventions for children on the autism spectrum (National Development and Reform Commission, 2022). Thus, evaluation of interventions to improve communication for children on the autism spectrum is an urgent priority.

The picture exchange communication system (PECS) is a visual augmentative and alternative communication (AAC) system and protocol that teaches participants to communicate using an increasingly complex repertoire of pictures (Bondy & Frost, 1994). The implementation of PECS starts with identifying each participant's preferred items. This is followed by six training phases (Bondy & Frost, 1994). Each training phase involves a participant and a communication partner to whom the participant delivers pictures in exchange for real, preferred items.

✉ Sheng Xu
sxu@ed.ecnu.edu.cn

Yan Li
1241324545@qq.com

Gabrielle T. Lee
glee329@uwo.ca

Yan Qi
1040857350@qq.com

[1] Faculty of Education, East China Normal University, 3663 N. Zhongshan Rd, Putuo District, Shanghai, China

[2] Faculty of Education, Western University, 1137 Western Road, London, Canada

[3] Rehabilitation Research Center of Shandong Province, No. 3126 Weizi Road, Tangye New District, Licheng District, Jinan City, Shandong Province, China

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Also present during training is a prompter whose role is to physically signal the participant to express requests.

In training phase one, the prompter physically guides the participant to pick up a picture of a preferred item and deliver the picture to the communication partner in exchange for the real item. Phase two involves introducing a PECS book with a picture of one of the participant's preferred items placed on the cover. The communication partner, participant, and the PECS book are initially physically close to each other but the communication partner gradually moves away from the participant so that the participant has to move to deliver the picture and receive the preferred item. As phase two proceeds, the communication partner also begins gradually to increase the distance between the PECS book and the participant so that the three form a triangle. The participant first has to move to access the picture on the PECS book and then move again to deliver the picture to the communication partner. The prompter uses physical prompts or eye gaze to direct the participant's movements.

During phase three, one picture of a preferred item and another picture of a nonpreferred item are placed on the cover of the PECS book. If a participant selects the preferred picture and delivers it to the communication partner, the communication partner gives the participant the real item. If the participant selects the nonpreferred picture, the participant is given the nonpreferred item. When the participant reacts negatively to receiving the nonpreferred item, an error correction sequence (which includes demonstrating, prompting, switching, and repeating) is initiated. When a participant is able to distinguish between one preferred and one nonpreferred picture, two preferred pictures are introduced, then three, four, and five pictures until, finally, participants select pictures from within the PECS book.

During the initial part of phase four, a picture or card with "I want" written at the left end of a sentence strip is presented to the participant; the communication partner physically prompts the participant to place the preferred item on the right-hand side of the sentence strip. The participant hands the sentence strip to the communication partner in exchange for the real item. Phase five involves teaching participants to answer when their communication partners ask, "What do you want?" Phase six teaches participants to make spontaneous responses to questions from their communication partners such as "What do you see?" (Frost & Bondy, 2014). Through the six PECS phases, participants can achieve functional communication—behavior directed toward another person who in turn provides real or social rewards (Bondy, 2001).

To date, many studies have reviewed literature published in English on PECS interventions (Flippin et al., 2010; Hart & Banda, 2009; Ostryn et al., 2008; Tincani & Devis, 2010), including studies involving people with developmental disabilities (Hart & Banda, 2009), special needs (Tincani & Devis, 2010), or ASD (Flippin et al., 2010; Ostryn et al., 2008). Hart and Banda (2009), for example, reviewed 13 single-case design (SCD) studies to examine the effectiveness of PECS interventions with people with developmental disabilities. Results showed PECS increased functional communication for 35 of 36 participants, increased speech for four of five participants, and decreased problem behavior for six of ten participants. Tincani and Devis (2010) performed a meta-analysis of 16 SCD studies of PECS interventions with people with special needs. Results suggested that PECS was moderately effective in establishing mands (requests) for participants up to PECS phase four. Flippin et al. (2010) reviewed eight SCD studies and three group studies conducted between 1994 and 2009 that evaluated the effectiveness of PECS in improving communication skills and speech for children on the autism spectrum. Results indicated that PECS was effective in increasing non-vocal communication behavior, but the data were not as clear for speech outcomes. Limited evidence supported the generalization and maintenance of improved communication behavior and speech as a result of PECS interventions (Flippin et al., 2010; Hart & Banda, 2009; Ostryn et al., 2008). The studies included in these systematic reviews did not report the study locations. We speculate, however, based on the affiliations of the authors of those studies, that the majority (more than 90%) were conducted in Western countries.

Wang et al. (2019) summarized and analyzed ASD intervention methods used by 36 agencies in Mainland China and reported that 72% of agencies implement PECS. PECS appears to be a very prevalent intervention approach. However, it is not yet clear whether the differences in outcomes that are found in earlier studies primarily undertaken in Western countries should reasonably be expected among participants in China. Some evidence suggests that Western societies are not representative of global populations (Henrich et al., 2010), which could lead to different outcomes of PECS training with Western samples compared to non-Western samples. Disparate outcomes could be caused, for example, by differences in language structure and cultural practices. It is, therefore, important to evaluate the effects of PECS conducted with Chinese-speaking samples in China.

Chinese scholars have reviewed the effects of PECS on communication skills and speech development in people on the autism spectrum (He & Li, 2020; Zhou & Cheng, 2016). Zhou and Cheng (2016) reviewed six randomized controlled trial studies conducted between 2014 and 2016 that illustrate the effects of PECS on communication

behavior and speech development—five studies published in international journals in English and one published in a Chinese journal. The findings indicated that PECS was effective in increasing communication behavior but yielded inconsistent effects on speech development. He and Li (2020) examined the effect of PECS intervention in 18 SCD studies and seven group studies published in international journals in English between 2009 and 2020. Their conclusion was similar to that of Zhou and Cheng (2016) that PECS is effective in increasing communication behavior, but that results are mixed concerning speech outcomes. None of these reviews, however, focused specifically on the use of PECS with Chinese-speaking samples nor did they report when the reviews were conducted or clarify their sampling procedures. The current effectiveness of PECS interventions for Chinese samples in China thus still remains largely unknown.

The purpose of our review was to provide a systematic analysis of PECS SCD studies conducted with people on the autism spectrum in Mainland China. The percentage of non-overlapping data points (PNDs) (Scruggs et al., 1987) was used as an effect size to report intervention effectiveness. Our review addressed the following research questions: (1) What are the effects of PECS on non-vocal communication skills, speech, and problem behavior? (2) When non-vocal communication skills and speech are increased and problem behaviors decreased, to what extent are these changes maintained and generalized outside of PECS interventions? (3) To what extent is PECS a socially valid intervention? (4) To what extent are the PECS SCD studies conducted in China methodologically rigorous?

Method

Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Page et al., 2021) was used to systematically guide the search process and the review of PECS intervention studies conducted with Chinese samples on the autism spectrum in Mainland China.

Information Sources and Search Strategy

An electronic database search was conducted using three Chinese databases—the China National Knowledge Infrastructure (CNKI), WeiPu, and Wanfang—which are the most frequently used academic databases in Mainland China (Liao et al., 2020). English databases included ERIC (Educational Resources Information Center-ProQuest), ProQuest Social Science, EBSCO Information Services, and Web of Science. The literature search on CNKI was conducted on 16 January 2022, on Wanfang on 24 January 2022, and on WeiPu on 3 February 2022. The search on the four English databases took place on 3 February 2022.

In the three Chinese language databases, we used the following search terms: (1) autism ("自闭症" or "孤独症" or "自闭症谱系障碍" or "孤独症谱系障碍" or "ASD") AND (2) picture exchange communication system OR augmentative alternative communication ("图片兑换沟通系统" or "图片交换沟通系统" or "图片交换" or "图片兑换" or "PECS" or "扩大替代性沟通" or "AAC" or "沟通" or "言语" or "语言"). In the English language databases, we used the search terms used in previously published reviews (Hart & Banda, 2009; Ostryn et al., 2008). These were (1) autis*

Table 1 Search terms

Databases and search strategy	Yield
CNKI: (SU = 自闭症 OR SU = 孤独症 OR SU = 自闭症谱系障碍 OR SU = 孤独症谱系障碍 OR SU = ASD) AND (SU = 图片兑换沟通系统 OR SU = 图片交换沟通系统 OR SU = 图片兑换 OR SU = 图片交换 OR SU = PECS OR SU = 扩大替代性沟通 OR SU = AAC OR SU = 沟通 OR SU = 语言 OR SU = 言语), 限制同义词扩展	2177
WeiPu: (M = 自闭症 OR M = 孤独症 OR M = 孤独症谱系障碍 OR M = 自闭症谱系障碍 OR M = ASD) AND (M = 图片兑换沟通系统 OR M = 图片交换沟通系统 OR M = 图片兑换 OR M = 图片交换 OR M = PECS OR M = 扩大替代性沟通 OR M = AAC OR M = 沟通 OR M = 语言 OR M = 言语)	908
Wanfang: (主题:(自闭症) or 主题:(孤独症) or 主题:(自闭症谱系障碍) or 主题:(孤独症谱系障碍) or 主题:(ASD)) and (主题:(图片兑换沟通系统) or 主题:(图片交换沟通系统) or 主题:(图片兑换) or 主题:(图片交换) or 主题:(PECS) or 主题:(扩大替代性沟通) or 主题:(AAC) or 主题:(沟通) or 主题:(语言) or 主题:(言语))	4290
EBSCO: (SU "autis*") AND (SU "picture exchange communication system" OR SU "picture exchange" OR SU "PECS" OR SU "augmentative alternative communication" OR SU "AAC" OR SU "communication" OR SU "speech") AND (SU "China") Limiters: full-text, peer-review	36
Web of science: TS = (autis*) AND TS = (picture exchange communication system OR picture exchange OR PECS OR augmentative alternative communication OR AAC OR communication OR speech) AND TS = (China)	136
ERIC: su(autis*) AND su(picture exchange communication system OR picture exchange OR PECS OR augmentative alternative communication OR AAC OR communication OR speech) AND su(China) Limiters: peer review	16
ProQuest Social Science: su(autis*) AND su(picture exchange communication system OR picture exchange OR PECS OR augmentative alternative communication OR AAC OR communication OR speech) AND su(China) Limiters: full-text, peer review	2

AND (2) picture exchange communication system OR picture exchange OR PECS OR augmentative alternative communication OR AAC OR communication OR speech AND (3) China. Table 1 provides details about the search terms and fields. These searches returned 7565 articles which we then screened by hand to select those that met our eligibility criteria.

Eligibility Criteria and Study Selection

Studies that met the following criteria were selected for our review: (a) participants were people on the autism spectrum; (b) participants were taught any or all of the six PECS training phases; (c) the study design was a single-case design (SCD) which reported quantitative data, including graphs, for baseline and intervention treatments; (d) the study was conducted using a Chinese-speaking sample in China. Studies were excluded if any of the following criteria applied: (a) the study did not focus on PECS interventions; (b) the study was non-experimental and provided only descriptive data; (c) full text was not available; (d) the study used a group research design; (e) the study was a review. Studies in other Chinese-speaking areas such as Hong Kong and Taiwan were excluded because those regions have different databases and academic management systems than those in Mainland China.

Following the removal of duplicate articles ($n = 313$), we first screened by reading the titles and abstracts of 7252 articles to determine their relevance to PECS and their potential eligibility. Next, we downloaded the full texts of 242 articles to further evaluate based on our eligibility criteria. Of these, 229 were excluded because they did not involve PECS intervention research ($n = 114$), or they were review articles ($n = 66$), non-experimental studies ($n = 20$), or group research designs ($n = 27$). A further two articles were excluded because the full text was not available after all ($n = 1$), or they were duplicate publications ($n = 1$). In the end, thirteen studies met all eligibility criteria. We then hand-searched the references of these studies, but no further studies were identified in this way. A PRISMA diagram of the exclusion procedure is shown in Fig. 1.

Data Extraction

The 13 selected studies were reviewed and coded in terms of the following features: (a) participant characteristics; (b) location and intervention setting; (c) preference assessment; (d) baseline conditions; (e) intervention characteristics; (f) PECS intervention outcome (including PNDs); (g) generalization and maintenance; (h) social validity; (i) experimental design and rigor. Participant characteristics were coded in the following order: age, gender, disability, cognitive level, communication ability, prerequisite skills, and ethnic group. Intervention characteristics were coded in terms of length and intensity of the training sessions, number of PECS phases implemented, and specific intervention procedures. The intervention outcome (including PNDs) was coded in terms of the type of non-vocal communication skill involved: picture exchange, non-vocal communication excluding picture exchange, non-vocal communication including picture exchange, speech, and problem behavior. The first author independently conducted all data extractions after which the third author blindly and independently rated 30% of the data extractions. Interobserver agreement (IOA) was 100%. More details about each of the selected studies are provided in Table 2.

Calculation of PNDs and Criteria for Effectiveness

PNDs for the 13 selected studies were calculated by visually identifying the extreme data point in the baseline phase and then the percentage of data points that exceeded that level during interventions (Scruggs et al., 1987). Specifically, in an intervention intended to improve behavior, the proportion of intervention data points that exceeded the highest baseline value was calculated; in an intervention intended to decrease problem behavior, the proportion of intervention data points that fell below the lowest baseline value was calculated. Interpretation of PND scores based on Scruggs et al. (1986) was as follows: PND values below 50% indicate that the intervention had little to no effect on the participant; values ranging from 50 to 70% indicate minimal effectiveness, values from 71 to 90% indicate moderate effectiveness, and values above 91% indicate high effectiveness. The first author independently calculated all PNDs. The third author blindly and independently rated 30% of PND calculations. IOA demonstrated 92% agreement. Discrepancies were solved through discussion with the fourth author to reach a consensus (Hu & Lee, 2018).

Experimental Rigor

Experimental rigor was assessed according to rubrics developed by Reichow (2011) which are summarized in Table 3. The rubrics include six primary quality indicators (participant characteristics, independent variables, dependent variables, baseline conditions, visual analyses, and experimental control) and six secondary quality indicators (interobserver agreement scores, kappa scores, fidelity scores, use of blind raters, measurement of generalization and/or maintenance, and social validity). Primary quality indicators were coded using a trichotomous scale to rate them as high, acceptable, or unacceptable; secondary quality indicators were examined using a dichotomous scale to rate them as having evidence or no evidence. An operational definition of the primary and secondary quality indicator measures can be

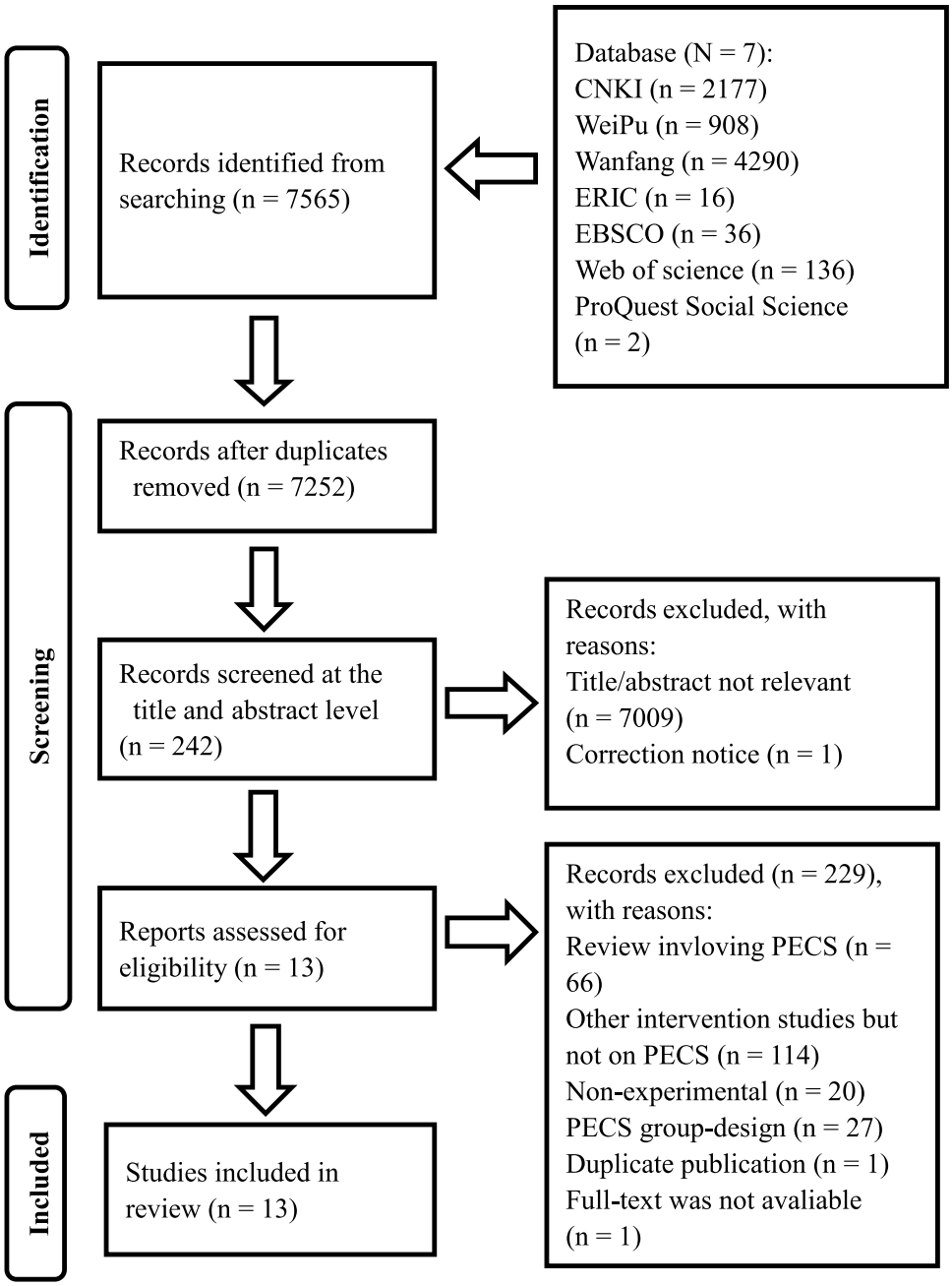

Fig. 1 PRISMA flow diagram for studies

found in Reichow (2011). Studies were rated as strong if they received high ratings on all the primary quality indicators and showed evidence of three or more secondary quality indicators; as adequate if they received high ratings on four or five primary quality indicators, had no unacceptable quality ratings on any primary quality indicators, and if they showed evidence of at least two secondary quality indicators; and as weak if they received fewer than four high ratings on primary quality indicators or showed evidence of fewer than two secondary quality indicators.

The formula proposed by Reichow (2011) was used to assess the overall rating of the studies to determine whether PECS can be considered an evidence-based intervention for Chinese-speaking samples on the autism spectrum. The first author independently conducted evaluations of experimental rigor. The third author blindly and independently rated 30% of the studies for experimental rigor. IOA was 94%. Discrepancies were solved through discussion with the fourth author to reach a consensus (Chen et al., 2020; Zhang, 2015).

Interobserver Agreement

All IOAs in this review were evaluated item-by-item. IOA was calculated by dividing the total number of items on

Table 2 Data extraction from selected studies

Author(s)	Participants (age; gender; disability; IQ)	Communication ability	Location and intervention setting	Length and intensity	Independent variable	Dependent variable	Percentage of non-overlapping data points
Chen (2019)	*N* = 3; A: 9 y, female, autism; B: 7 y, male, autism; C: 9 y, male, autism	A: non-vocal; B: few functional words; C: imitate phases when prompted, had stereotypy vocal	Xi'an (Northwest China); special education school	9 weeks; 5 times per week. 30 min per time	Using "新雨滴" application PECS phase 1–4	Increase frequency of PE and answer questions using the iPad	PE: A: 100%; B: 100%; C: 100%; answer question: A: 100%; B: 100%; C: 100%
Chen et al. (2020)	*N* = 3; A: 10.4 y, male, ASD; B: 10.9 y, male, ASD; C: 12.5 y, male, ASD	A: non-vocal; B: emit unclear voice when prompted; C: vocal stereotypy	NR; special education school	8 weeks; 3 times per week, 30 min per time	Video modeling-based PECS 1–4	Increase frequency of non-vocal including PE and reduce frequency of emotional behavior	Non-vocal including PE: A: 100%; B: 100%; C: 100%; problem behavior: A: 87.5%; B: 100%; C: 100%
Geng (2019)	*N* = 2; A: 16 y, male, ASD; B: 16 y, male, ASD	A: imitate phrases when prompted, emit "baba"; B: limited 4–5 vocal mands	Dalian (Northeast China); NR	6 weeks; 3 times per week	PECS phase 1–6	Increase frequency of non-vocal excluding PE and vocal mands	Non-vocal excluding PE: A: 100%; B:100%; vocal mands: A: 100%; B: 100%
Gu (2019)	*N* = 1; 6 y, male, autism	Non-vocal	NR	NR	PECS phase 1	Reduce frequency of aggression behavior, increase frequency of PE	PE: 76.5%; problem behavior: 80%
Hu and Lee (2018)	*N* = 1; 4 y, male, ASD, IQ = 43, severe	Imitate one-syllable approximations when specific establishing operations were present, eye contact and pointing	Northeastern China; early intervention center	9–27 sessions; 30 min per session	PECS phase 1–3	Increase frequency of PE, vocal mands, and reduce frequency of aggressive behavior	PE: NA; vocal mands: 55.6%; problem behavior: 67.3%
Li and Du (2016)	*N* = 1; 6 y, male, autism, moderate	Non-vocal	NR; inclusive preschool	4 weeks; 5 times a week, 45 min per time	PECS phase 1–3	Increase frequency of vocal mands and non-vocal excluding PE	Vocal mands: 10%; non-vocal excluding PE: 100%
Ling (2020)	*N* = 1; 9 y, male, autism, mild	Non-vocal	NR	2 weeks	PECS phase 1–3	Increase frequency of non-vocal excluding PE and vocal mands	Non-vocal excluding PE:100%; vocal mands:100%
Ma et al. (2021)	*N* = 3; A: 14 y, male, autism; B:14 y, male, autism; C: 6 y, female, autism	A: emit short phrase; B: emit 1 word, had vocal stereotypy; C: non-vocal	NR; early intervention center	3 months; 2 times per week, 30 min per session	PECS phase 1–6 vs using application in iPad phase 1–6	Increase the percentage of PE	PE: A:100%; B: 100%; C:70%; iPad-based PECS: A:84.2%; B:100%; C: 65.98%
Mao (2017)	*N* = 2; A: 10 y, male, autism; B: 11 y, male, autism	A: non-vocal; B: few functional words or phrases,	Hangzhou (East China); special education school	8 weeks; 3 times per week, 35 min per time	PECS phase 1–4	Increase frequency of vocal mands and non-vocal excluding PE	Vocal mand: A: 100%; B: 100%. Non-vocal excluding PE: A: 95.9%; B: 87.5%

Table 2 (continued)

Author(s)	Participants (age; gender; disability; IQ)	Communication ability	Location and intervention setting	Length and intensity	Independent variable	Dependent variable	Percentage of non-overlapping data points
Qi and Zhao (2018)	*N* = 1; 3.10 y, male, autism	Non-vocal	NR; inclusive preschool	14 weeks; 4 times per week. 30 min per time	PECS phase 1–4	Increase percentage of vocal mands and non-vocal including PE	Non-vocal including PE: 100%; vocal mands: 59.2%
Qian (2016)	*N* = 1; 8 y, male, autism, IQ = 42, mild	Imitate short sentence, usually emit phrases	Shanghai (East China); special education school	20 sessions; 3 times per week, 35 min per time	PECS phase 4	Increase frequency of vocal mands	Vocal mands: 100%
Zhang (2015)	*N* = 2; A: 6 y, male, autism, moderate; B: 6 y, male, autism, moderate	A: few functional words, body language, ignore refusal; B: non-vocal	Chongqing (Southwestern China); special education school	1 month; 3 times per week, 30 min per time	PECS phase 1–3 based PECS Phase III	Increase percentage of PE	PE: A: 100%; B: 100%
Zheng and Li (2017)	*N* = 1; 10 y, male, autism	Non-vocal	NR; special education school	20 sessions; 2 times per day, 30 min per time	PECS phase 1–3	Increase frequency of PE, reduce inappropriate behavior	PE: 100%; problem behavior: 100%

N participants' number, *y* years, *ASD* autism spectrum disorder, *IQ* intelligence quotient, *A* the first participant, *B* the second participant, *C* the third participant, *NR* not reported, *PECS* picture exchange communication system, *PE* picture exchange, *NA* not applicable

which the raters agreed by the total number of items and multiplying by 100. IOA was assessed to determine agreement between two independent assessors (the first and the third authors) on whether or not to include a study based on their evaluation of the literature search, title, abstract, and full-text screening. IOA was calculated as 100% for the literature search, 99.8% for title and abstract screening, and 95.4% for full-text screening. Discrepancies were resolved through discussion with the fourth author to reach a consensus (Huang, 2016; Lan, 2016; Liu, 2008; Tao, 2015; Wang, 2021; Wei & Xu, 2007; Xu, 2015; Xu, 2017; Yang, 2017; Ye & Zhang, 2020; Zhang & Zuo, 2015).

Results

Our selection process resulted in the selection of 13 studies from Chinese and English databases for systematic review. Four are master's dissertations, eight are peer-reviewed journal articles, and one is a conference paper.

Participant Characteristics

A total of 22 participants were involved across the 13 selected studies. Among the 22 participants, 21 were male, and one was female. All studies reported the age of the participants which averaged 9.2 years with a range from 3 years 10 months to 16 years.

Of the 22 participants, six had been diagnosed with ASD, the others with autism. Participants in the Hu and Lee (2018) study had been diagnosed with ASD using the Chinese version of the *Childhood Autism Rating Scale* (Lu et al., 2004). The other studies reported diagnostic results but did not report diagnostic instruments. Two studies (15%) reported the intelligence quotients (IQ) of two participants as 42 (Hu & Lee, 2018) and 43 (Qian, 2016). Five studies (38%) (Hu & Lee, 2018; Li & Du, 2016; Ling, 2020; Qian, 2016; Zhang, 2015) reported the severity of autism/ASD as moderate in three participants (Li & Du, 2016; Zhang, 2015) and mild to severe in three participants (Hu & Lee, 2018; Ling, 2020; Qian, 2016).

All selected studies described the participants' communication abilities. Five studies (38%) used the *Communication Behavior Scale for Children with Autism* (Chang, 2002) to measure participants' communication skills (Chen, 2019; Chen et al., 2020; Li & Du, 2016; Mao, 2017; Zhang, 2015). Ma et al. (2021) used the *Adaptive Behavior Assessment System (ABAS)* to report participant communication skills. Other studies described participants' communication skills without reporting which assessment instruments were used. Of the 22 participants, six were described as using few functional words or phrases to mand independently and six as able to imitate phases when prompted, demonstrate vocal

Table 3 Research Design and Rigor Rating

Author(s)	Research design	Primary quality indicators[a]						Secondary quality indicators[b]							Rigor rating[c]
		PC	IV	DV	BC	VA	EC	IOA	KAP	FID	BR	M	G	SV	
Chen (2019)	MPB	U	A	U	H	H	A	NE	NE	NE	NE	E	NE	NE	Weak
Chen et al. (2020)	MPP	U	H	H	A	A	H	NE	NE	NE	NE	E	NE	NE	Weak
Geng (2019)	ABC	U	A	U	A	H	U	NE	NE	NE	NE	E	NE	NE	Weak
Gu (2019)	ABC	U	A	U	A	A	U	NE	NE	NE	NE	E	NE	NE	Weak
Hu and Lee (2018)	MBS	U	H	H	U	U	U	E	NE	E	E	E	NE	E	Weak
Li and Du (2016)	ABAB	U	A	H	A	U	U	E	NE	E	NE	NE	NE	NE	Weak
Ling (2020)	AB	U	A	H	A	A	U	NE	NE	NE	NE	NE	NE	NE	Weak
Ma et al. (2021)	NMBP	U	H	H	A	H	U	NE	NE	NE	NE	E	NE	NE	Weak
Mao (2017)	ABAB + MBS	U	A	A	A	H	A	E	NE	NE	NE	NE	NE	NE	Weak
Qi and Zhao (2018)	ABC	U	A	H	A	U	U	E	NE	E	NE	E	NE	NE	Weak
Qian (2016)	ABC	U	A	U	A	H	U	NE	NE	NE	NE	E	NE	NE	Weak
Zhang (2015)	MBP	U	A	A	A	H	A	NE	NE	NE	NE	NE	NE	NE	Weak
Zheng and Li (2017)	ABC	U	A	U	A	H	U	NE	NE	NE	NE	E	NE	NE	Weak

MPB multiple probe across behaviors, *MPP* multiple probe across participants, *MPA* multiple baseline across activities, *MBS* multiple baseline across settings, *NMBP* noncurrent multiple baseline across participants, *MBS* multiple baseline across settings, *MBP* multiple baseline across participants, *PC* participant characteristics, *IV* independent variable, *DV* dependent variable, *BC* baseline condition, *VA* visual analysis, *EC* experimental control, *IOA* interobserver agreement, *KAP* Kappa, *FID* fidelity, *BR* blind raters, *M* maintenance, *G* generalization, *SV* social validity, *A* acceptable quality, *H* high quality, *U* unacceptable quality, *NE* no evidence, *E* evidence

[a]Criteria for evaluating primary quality indicators:

Participant characteristics (age and gender, diagnosis and diagnostic instrument, standardized test scores, interventionist's and secondary participants characteristics); baseline condition (three measurement points, stable, no trend, operationally defined); dependent variable (operationally defined, sufficient detail provided for replication, linked to dependent variables, data collected at appropriate times); visual analysis (data are stable, < 25% overlap of data points, a large shift in level or trend); independent variable; experimental control. Evaluation of primary quality indicators (H = high; A = acceptable; U = unacceptable). Participant characteristics, baseline condition, dependent variable, visual analysis: (H, all criteria met; A, two or more criteria met; U, two or fewer criteria met); independent variable (H, defined in sufficient detail to be precisely replicable; A, many elements defined but specific details omitted; U, insufficiently defined); experimental control (H, 3 demonstrations; A, 2 demonstrations: U, 1 demonstration or no demonstrations)

[b]Criteria for evaluating secondary quality indicators: interobserver agreement (IOA) (reliability across all conditions > 0.80); kappa (> 20% of sessions across all conditions, > 0.60); blind raters (raters were blind to the condition); fidelity (data gathered across conditions, > 0.80); generalization or maintenance (data collected after the intervention); social validity (social importance, effectiveness, significance, satisfaction, normative references for behavioral performance for typically developing children, in a natural context, intervention implemented by people who typically have contact with the participant). Evaluation of secondary quality indicators (E = Evidence; NE = No evidence). Studies that met all criteria for secondary quality indicators (IOA, kappa, fidelity, blind raters, and maintenance and generalization) and four or more criteria for social validity are rated "E." Studies that did not meet these criteria are rated "NE."

[c]Overall evaluation of the studies (S = strong; A = adequate; W = weak). Studies that received high ratings on all the primary quality indicators and showed evidence of three or more secondary quality indicators were rated 'strong'. Studies that received high ratings on four or five primary quality indicators had no unacceptable ratings on any primary quality indicators and showed evidence of at least two secondary quality indicators were rated "adequate." Studies that received fewer than four high ratings on primary quality indicators or showed evidence of fewer than two secondary quality indicators were rated "weak"

stereotypy, or emit one-word or one-syllable responses. Ten participants were described as non-vocal.

Five studies (38%) reported that participants had fine motor skills (Geng, 2019; Li & Du, 2016; Qi & Zhao, 2018; Qian, 2016; Zhang, 2015). Three studies reported that fine motor skills included picking up a picture card with two fingers and tearing and sticking pieces of Velcro (Geng, 2019; Li & Du, 2016; Qi & Zhao, 2018). Two studies reported fine motor skills that included paper cutting or writing (Qian, 2016; 2018; Zhang, 2015). Four studies (31%) reported that participants had motor imitation skills or received motor programming (Geng, 2019; Hu & Lee, 2018; Ma et al., 2021; Qian, 2016), but these studies did not describe specific motor imitation skills. One study (8%) reported that participants could distinguish pictures (Zheng & Li, 2017). One study (8%) reported that participants could match pictures and corresponding nonidentical items (Hu & Lee, 2018). None of the selected studies reported the ethnic backgrounds of participants.

Location and Intervention Setting

Of the 13 studies, six (46%) reported the location where the studies were conducted; these included the Western,

Northeast, and Northern parts of China (Chen, 2019; Geng, 2019; Hu & Lee, 2018; Mao, 2017; Qian, 2016; Zhang, 2015). Ten studies (77%) reported intervention settings (Chen, 2019; Chen et al., 2020; Hu & Lee, 2018; Li & Du, 2016; Ma et al., 2021; Mao, 2017; Qi & Zhao, 2018; Qian, 2016; Zhang, 2015; Zheng & Li, 2017). Six of these studies (46%) took place in special education schools (Chen, 2019; Chen et al., 2020; Mao, 2017; Qian, 2016; Zhang, 2015; Zheng & Li, 2017), two (15%) took place in inclusive preschool classrooms (Li & Du, 2016; Qi & Zhao, 2018), and two were conducted in individual therapy rooms at early intervention centers (Hu & Lee, 2018; Ma et al., 2021). The setting in which Hu and Lee (2018) implemented PECS also included the playground of the early intervention center and the participants' homes.

Preference Assessment

The first step in PECS intervention is to determine the participants' preferred items (Bondy & Frost, 1994). Except for the Ling (2020) and Gu (2019) studies, the other eleven studies (85%) conducted preference assessments. Nine studies (69%) used parent reports, and two studies (15%) used parent reports combined with formal assessments (single stimulus or multiple stimulus without replacement) (Hu & Lee, 2018; Ma et al., 2021) to identify participants' preferred items.

Baseline Conditions

In four studies (31%), participants had access during baseline to preferred items and corresponding pictures or pictures displayed on an iPad (Chen, 2019; Chen et al., 2020; Ma et al., 2021; Zheng & Li, 2017). Participants in five studies (38%) had access to preferred items but without corresponding pictures available (Hu & Lee, 2018; Li & Du, 2016; Ling, 2020; Mao, 2017; Qian, 2016). Four studies (31%) did not specify baseline conditions (Geng, 2019; Gu, 2019; Qi & Zhao, 2018; Zhang, 2015).

Intervention Characteristics

Length and Intensity of Training Sessions

Twelve studies (92%) (the exception was Gu, 2019) described the length and intensity of PECS intervention sessions. The total length of the intervention ranged from 2 to 14 weeks, with the average being 7 weeks.

PECS Phases

Of the 13 selected studies, two studies (15%) attempted to implement all six PECS phases (Geng, 2019; Ma et al., 2021). All participants in five studies (38%) (Hu & Lee, 2018; Li & Du, 2016; Ling, 2020; Zhang, 2015; Zheng & Li, 2017) were taught PECS phases one through three. All participants in four studies (31%) (Chen, 2019; Chen et al., 2020; Mao, 2017; Qi & Zhao, 2018) were taught PECS phases one through four. Participants in Chen (2019) were also taught to answer questions using an iPad. The participant in Qian (2016) was taught PECS phase four because that participant demonstrated mastery of previous PECS phases in pre-experimental probe sessions. The participant in Gu (2019) was taught PECS phase one.

Researchers reported that 17 of 22 participants (77%) successfully mastered the six PECS phases targeted in the 13 studies. None of the five participants in Ma et al. (2021) and Geng (2019), however, completed all their target PECS phases; two of the five completed PECS phases one through four, one completed PECS phases one and two, one completed PECS phases one through three, and one completed PECS phases one through five.

Two studies (15%) did not specify the criterion for mastery of PECS phases (Gu, 2019; Qian, 2016). One study (8%) set the criterion for mastery of PECS phases at 100% for three consecutive sessions (Qi & Zhao, 2018). Three studies (23%) adopted 90% or 80% as the mastery criterion (Geng, 2019; Mao, 2017; Zheng & Li, 2017) but did not report the number of sessions required to reach that criterion. Seven studies (54%) set the criterion for mastery of PECS phases at 80% or above for two or three consecutive sessions (Chen, 2019; Chen et al., 2020; Hu & Lee, 2018; Li & Du, 2016; Ling, 2020; Ma et al., 2021; Zhang, 2015). Four studies (31%) reported the number of trials needed by the participants to complete the number of PECS phases targeted in the studies (Chen et al., 2020; Hu & Lee, 2018; Ma et al., 2021; Qi & Zhao, 2018). Participants in Qi and Zhao (2018) and Chen et al. (2020) used on average 270 and 233 trials respectively to complete PECS phases one through four. Hu and Lee (2018) reported that their participant completed PECS phases one through three in three settings, using 150 to 436 trials. Ma et al. (2021) reported that three participants required 208, 192, and 384 trials to complete five, four, and three phases of PECS, respectively, while participants used 352, 208, and 240 trials to complete the communication intervention using the "静待花开 [jingdaihuakai]" application in iPad.

Intervention Procedures

Of the 13 selected studies, researchers in two studies (15%) referred to the PECS manual (Frost & Bondy, 2014) for guidance on how to develop participants' communication behavior (Chen et al., 2020; Hu & Lee, 2018). Three studies (15%) used an application named "新雨滴 [xinyudi]," "PECS Phase III," and "jingdaihuakai" to promote communication skills for

participants (Chen, 2019; Ma et al., 2021; Zhang, 2015). Both "xinyudi" and "jingdaihuakai" are AAC mobile applications available for download from the Android and Apple Store. "PECS Phase III" application is designed for iPad. One study (8%) compared the effect of the "jingdaihuakai" application and PECS using a picture book (Ma et al., 2021). The procedure used by Chen (2019) and Zhang (2015) was identical to that provided in the PECS manual except that the picture was displayed on the iPad, and the participants clicked on the pictures to complete the exchange. The procedures used by Ma et al. (2021) involved dragging the picture on the iPad into the sentence box. For example, in PECS phase one, participants dragged the picture into the sentence box, pressed a button to make the sound of the picture, and handed the iPad to the communicator to make the request. Two studies (15%) used verbal instructions (e.g., give me the picture of the apple, or give me the picture) to guide participants to initiate communication. In addition to verbal instruction, both studies used gestural, modeling, and physical prompts (Gu, 2019; Zheng & Li, 2017). Two studies (15%) used modeling to teach participants to start communication (Chen et al., 2020; Qian, 2016). Chen et al. (2020) used video modeling to teach PECS to children and adolescents on the autism spectrum; within 15 min, participants watched the PECS model video two to five times and then performed PECS within 10 s. Qian (2016) modeled how to stick a picture of the desired item after the "I want" sentence stem to form the sentence "I want a red apple."

Three studies (23%) supported parent involvement in PECS intervention (Gu, 2019; Hu & Lee, 2018; Zheng & Li, 2017). In these studies, parents were trained as communication partners or paraeducators; in Gu (2019), parents participated as physical partners and communicators, and in Zheng and Li (2017), parents participated as prompters. Hu and Lee (2018) reported that parents were trained to implement PECS for the purpose of promoting skill generalization. None of the three studies mentioned the process by which parents received PECS training.

PECS Intervention Outcome

Dependent variables in the selected studies included non-vocal communication skill, speech, and problem behavior. Non-vocal communication skill is subdivided into picture exchange, non-vocal communication behavior excluding picture exchange, and non-vocal communication behavior including picture exchange. For studies with more than one intervention setting, the effectiveness of PECS intervention on each dependent variable is indicated by the average of the PNDs for each setting.

Non-vocal Communication Skill

Researchers in 12 studies (92%) targeted non-vocal communication behaviors for 21 participants. PND was calculated for 20 participants (Hu & Lee, 2018, excepted). PND values indicated PECS was highly or moderately effective in increasing non-vocal communication behavior for 19 participants and minimally effective for one participant.

Picture Exchange

Picture exchange refers to a participant taking the picture/iPad to the communication partner and presenting it in exchange for a real, preferred item. Six studies (46%) with a total of 11 participants used the frequency of picture exchange as dependent variables (Chen, 2019; Gu, 2019; Hu & Lee, 2018; Ma et al., 2021; Zhang, 2015; Zheng & Li, 2017). One study (8%) involving one participant did not collect baseline data for picture exchanges (Hu & Lee, 2018). PECS was a highly or moderately effective intervention for 10 participants for whom PND values ranged from 76.5 to 100% (Chen, 2019; Gu, 2019; Zhang, 2015; Zheng & Li, 2017), and a minimally effective intervention for one participant for whom PND values ranged from 65.98 to 70% (PECS vs communication using the "jingdaihuakai" application in iPad, Ma et al., 2021). In a comparative study with three participants (Ma et al., 2021), PND indicated that the intervention effect of PECS was better than that of communication using the "jingdaihuakai" application in iPad for two participants, while for the other participant, the intervention effect of PECS was the same as that of communication using the "jingdaihuakai" application in iPad.

Non-vocal Communication Excluding the Use of Picture Exchange

Non-vocal communication excluding the use of picture exchange refers to participants using only eye contact, pointing, gesture, pulling, grabbing, and reaching. Four studies (31%) with a total of six participants targeted non-vocal communication excluding the use of pictures to communicate (Geng, 2019; Li & Du, 2016; Ling, 2020; Mao, 2017). PECS was highly effective for five participants for whom average PND values ranged from 95.9 to 100% (Geng, 2019; Li & Du, 2016; Ling, 2020), and moderately effective for one participant for whom PND values were 87.5% (Mao, 2017). Participants in Mao (2017) showed highly or moderately increased non-vocal communication behaviors in individual room settings and craft lesson settings.

Non-vocal Communication Including the Use of Picture Exchange

Non-vocal communication including the use of picture exchange refers to participants using eye contact, pointing, gesture, pulling, grabbing, and reaching as well as picture exchange to communicate. Two studies (15%) with a total of

four participants targeted non-vocal communication including picture exchange communication (Chen et al., 2020; Qi & Zhao, 2018). PECS was a highly effective intervention for all participants whose PND values were all 100%.

Speech

Speech is classified into two types: word, phrase, or sentence vocalizations, and vocal/word approximations (Hart & Banda, 2009). Word, phrase, and sentence vocalizations refer to participants clearly saying the correct name of the item they are manding (e.g., "Cookie; I want cookies"). Vocal/word approximations refer to participants emitting vocalizations/words that are not clearly the name of the manded item (e.g., a "pin" sound is an approximation for "pingguo" which means "apple" in Mandarin Chinese). Seven studies (54%) with a total of nine participants targeted for increase in speech (Geng, 2019; Hu & Lee, 2018; Li & Du, 2016; Ling, 2020; Mao, 2017; Qi & Zhao, 2018; Qian, 2016). PECS intervention was highly effective for six participants (Geng, 2019; Ling, 2020; Mao, 2017; Qian, 2016) for whom PND values were all 100% but had minimal or little to no effect for three participants for whom PND values ranged from 10 to 59.2% (Hu & Lee, 2018; Li & Du, 2016; Qi & Zhao, 2018). In Li and Du (2016) and Ling (2020), the target speech was the vocalization of the short "a" sound. Mao (2017) and Qi and Zhao (2018) defined speech as words, phrases, or short sentences. Hu and Lee (2018) defined vocal mands as word approximations or a spoken intelligible word. Qian (2016) defined speech as the use of a complete sentence to express the mand. Both Qi and Zhao (2018) and Hu and Lee (2018) found that participants' speech increased during PECS phase three.

Problem Behavior

Problem behavior refers to a participant engaging in aggressive behavior (e.g., hitting, biting others) or other inappropriate behavior (e.g., throwing things). The effectiveness of PECS in decreasing problem behavior was reported for six participants in four studies (31%) (Chen et al., 2020; Gu, 2019; Hu & Lee, 2018; Zheng & Li, 2017). PND values indicated PECS was a highly or moderately effective intervention in decreasing problem behavior for five of six participants for whom PND values ranged from 80 to 100% (Chen et al., 2020; Gu, 2019; Zheng & Li, 2017) and had minimal effect with one participant for whom the PND value was 67.3% (Hu & Lee, 2018).

Two studies (15%) conducted functional assessments of problem behavior: Gu (2019) conducted a brief functional analysis while Hu and Lee (2018) combined natural observations and anecdotal reports using the Chinese version of the *Functional Assessment Interview Form* (O'Neill et al., 2014) to assess behavior. Gu (2019) conducted an experiment to verify the function of problem behavior; the procedural descriptions of functional analysis and the data provided in the graph, however, were not clear. The behavioral functions of Gu's participant (2019) were to obtain tangible items and attention. The behavioral functions of the participant in Hu and Lee (2018) were to obtain tangible items.

Generalization and Maintenance

No studies reported the generalization of acquired communicative responses to new picture stimuli or to different people or in different settings than those involved in the initial PECS instruction. Three studies (23%), however, programmed for generalization of the intervention by teaching PECS in various settings (Qi & Zhao, 2018; Zheng & Li, 2017) using similar but different pictures (Hu & Lee, 2018) or using new communication partners (Hu & Lee, 2018; Qi & Zhao, 2018; Zheng & Li, 2017).

Nine studies (69%) collected maintenance data following the completion of interventions with 16 participants—data related to increasing non-vocal communication behaviors ($n = 15$ participants), increasing speech ($n = 8$ participants), and decreasing problem behaviors ($n = 6$ participants) (Chen, 2019; Chen et al., 2020; Geng, 2019; Gu, 2019; Hu & Lee, 2018; Ma et al., 2021; Qi & Zhao, 2018; Qian, 2016; Zhang, 2015). Six studies (46%) conducted maintenance probe sessions immediately after the PECS mastery criterion was reached (Chen, 2019; Geng, 2019; Gu, 2019; Qi & Zhao, 2018; Qian, 2016; Zheng & Li, 2017). Three studies (23%) collected maintenance data 1 week to 8 weeks after the completion of the intervention (Chen et al., 2020; Hu & Lee, 2018; Ma et al., 2021). All participants continued performing communication behaviors at a high level following the completion of the PECS intervention; as well, problem behavior was decreased and maintained at a low level.

Social Validity

Five studies (38%) reported the social validity of the PECS intervention as assessed by parents or teachers, or both (Hu & Lee, 2018; Li & Du, 2016; Ma et al., 2021; Mao, 2017; Qi & Zhao, 2018). Four studies (31%) reported on how social validity was measured (Hu & Lee, 2018; Li & Du, 2016; Ma et al., 2021; Mao, 2017). Two studies (15%) used questionnaires comprising items on a five-point scale and one open-ended question (Hu & Lee, 2018; Ma et al., 2021), and two studies (15%) surveyed social validity using only open-ended questions (Li & Du, 2016; Mao, 2017). The average score for acceptability, feasibility, satisfaction, and helpfulness of PECS interventions was 4.75 (SD = 0.12) in Hu and Lee (2018), and the average score for effectiveness, significance, and satisfaction was 4.57 (SD = 0.23) in Ma et al. (2021). Qi and Zhao

(2018) reported that teachers and parents found that the speech and imitation vocalizations of participants increased after PECS intervention. Li and Du (2016) and Mao (2017) reported that both teachers and parents were receptive to the PECS intervention and that parents found their children continuing to use picture exchange to mand for items in daily life.

Experimental Design and Rigor

Five studies (38%) used multiple-baseline or multiple-probe designs (Chen, 2019; Chen et al., 2020; Hu & Lee, 2018; Ma et al., 2021; Zhang, 2015). One study (8%) used an ABAB reversal design (Li & Du, 2016), six studies (46%) used an ABC/AB design (Geng, 2019; Gu, 2019; Ling, 2020; Qi & Zhao, 2018; Qian, 2016; Zheng & Li, 2017), and one study (8%) used both multiple-baseline and ABAB designs (Mao, 2017).

The primary quality indicators in 13 studies all included one or more unacceptable rating; as well, secondary quality indicators in 10 studies (77%) failed to meet the evidence criterion. All the studies, therefore, were rated as weak according to Reichow's scale (2011). None of the studies rated a high or acceptable quality rating for participant characteristics but all received high or acceptable ratings for the independent variable. Twelve of the 13 studies (92%) (Hu & Lee, 2018, was the exception) received high or acceptable ratings for the baseline condition; eight (62%) received high or acceptable ratings for the dependent variables (Chen et al., 2020; Hu & Lee, 2018; Li & Du, 2016; Ling, 2020; Ma et al., 2021; Mao, 2017; Qi & Zhao, 2018; Zhang, 2015); ten (77%) received high or acceptable ratings for visual analysis (Chen, 2019; Chen et al., 2020; Geng, 2019; Gu, 2019; Ling, 2020; Ma et al., 2021; Mao, 2017; Qian, 2016; Zhang, 2015; Zheng & Li, 2017); and four (31%) received high or acceptable ratings in experimental control (Chen, 2019; Chen et al., 2020; Mao, 2017; Zhang, 2015). None of the studies reported data on Kappa. One study (8%) reported using blind raters for IOA and procedural fidelity (Hu & Lee, 2018). Four studies (31%) reported data on IOA assessed for 20 to 50% of sessions across conditions with an average IOA ranging from 85 to 94% (Hu & Lee, 2018; Li & Du, 2016; Mao, 2017; Qi & Zhao, 2018), and three studies (23%) reported procedural fidelity assessed for 10 to 50% of sessions across conditions with an average IOA ranging from 90 to 98% (Hu & Lee, 2018; Li & Du, 2016; Qi & Zhao, 2018).

Discussion

The purpose of our review was to systematically evaluate SCD studies of PECS interventions with Chinese-speaking people on the autism spectrum. Thirteen studies were selected and analyzed. The PND indicated that PECS is effective in increasing communication behavior in Chinese-speaking people on the autism spectrum. The studies, however, lacked the necessary experimental rigor for SCD research, and we are unable to conclude that PECS intervention is an effective evidence-based practice for Chinese-speaking people on the autism spectrum.

In terms of participant characteristics, the scarcity of information about diagnostic instruments, symptom severity, IQ score, and ethnic background made it difficult to compare intervention outcomes across studies. China has diverse ethnic groups which represent different cultures and languages (Sun et al., 2013). Such differences may influence environmental factors that affect verbal acquisition (Brodhead et al., 2014). Future studies should report richer background information on participants and consider the influence that different ethnic backgrounds may have on the effectiveness of PECS interventions.

Fewer than half of the selected studies reported the location where the study was conducted. Of the studies that reported location, none were conducted in south or central regions of China or in National Autonomous Regions such as Xinjiang and Tibet. Because China has a vast geography with ethnically diverse populations and various levels of economic development, future research should report the location of studies to facilitate analysis of the influence of economic and cultural factors on PECS interventions.

More than half of the interventions in our selected studies were conducted in relatively isolated or restricted settings, such as in a separate room in a special education school or early intervention center (Chen, 2019; Chen et al., 2020; Hu & Lee, 2018; Ma et al., 2021; Mao, 2017; Qian, 2016; Zhang, 2015; Zheng & Li, 2017). It is important to teach the PECS target skills in the environment in which the participants live, work, and play, such as in the regular classroom, playground, or at home, in order to obtain natural consequences and maximize communicative opportunities. Future research should explore how to implement PECS intervention in natural settings.

PECS begins by teaching spontaneous mands; these can be taught only if the experimenter knows what a participant wants (Bondy & Frost, 1994). Thus, preference assessment may influence the effectiveness of PECS interventions in increasing functional communication. Few of our selected studies, however, ($n = 2$), used stimulus preference assessments to identify participants' preferred items. Future research should employ stimulus preference assessment for participants.

More than half of our selected studies reported that participants were instructed in PECS phase one through three or four, but only a few included PECS phases five and six. Two reasons may account for this. First, limited

experimental time meant that participants in some studies simply did not have enough time to reach these two final phases (e.g., Geng, 2019). Second, the lack of ability to discriminate between different pictures in phase three (i.e., between pictures of preferred items and nonpreferred items) would prevent some participants from proceeding to PECS phases four, five, and six. Future research should conduct comprehensive assessments of prerequisite communication skills for each participant and provide detailed descriptions of participants' speaker and listener behavior.

Gu (2019) used only PECS phase one with the participants in that study; ending after phase one, however, may not have permitted participants to acquire the relevant components of a functional communication repertoire because phase one's context is highly contrived: the communication partner and a single picture of the child's preferred items are close together and in front of the child (Bondy, 2001). Future research should explore how much each PECS phase adds to functional communication.

Ma et al. (2021) found that PECS using a picture book and using an application on an iPad were equally effective but consistent with the findings of Agius and Vance (2016), communication using a picture book appeared to be more efficient in that it required fewer trials for two participants than communication using an application in iPad. Two reasons may explain this result. It may be that communication using an application on the iPad required more prompting to produce a response because participants were required to touch the requested items on the screen before handing it to the communicator. Another possibility concerns each participant's modality preference which affects the number of experimental trials required. Ma et al. (2021) suggested that using the participant's preferred method—book versus iPad—might facilitate faster skill acquisition. However, this is speculation and requires further investigation. In the future, comparative studies should be conducted to determine the difference between different AAC systems so that the most suitable communication tools can be selected for use with each participant.

Less than 30% of participants demonstrated an increase in speech, and it remains to be determined whether it is at PECS phase three or four that speech begins to increase. Two studies reported that speech increased in PECS phase three (Hu & Lee, 2018; Qi & Zhao, 2018); previous findings, however, suggested that speech did not substantially increase until phase four (Tincani et al., 2006). Hu and Lee (2018) speculated that discrimination training in phase three established the connection between pictures and real items, and thereby led to increased speech. Tincani et al. (2006) suggested that the increase in speech in phase four was a function of speech reinforcement being delayed until this phase, making it appear that speech increased more at phase four than at phase three (Qi & Zhao, 2018; Tincani et al., 2006). Future research should further explore the relationship between PECS phases and increased speech.

Two factors may explain why less than 30% of participants showed increased speech. First, the number of spoken words a participant had before starting PECS may have affected the amount of speech they acquired from the PECS intervention. Researchers have suggested that participants who had at least a limited number of spoken words before PECS intervention were more likely to increase vocal speech than those who did not have a verbal repertoire (Ganz & Simpson, 2004). The fact that the majority of participants in the studies we reviewed did not have spoken words may, therefore, help to explain why changes in participants' speech were not reported. Second, limited increase in speech may be related to inappropriate addressing of problem behavior. Li and Du (2016), for example, concluded that ignoring some screams that may have had communicative intention may have affected the speech results they reported; that study, however, did not report any details about the screams, and it is impossible to evaluate how the screams influenced the speech acquisition.

Our PND data provide preliminary evidence that PECS was successful in increasing communication skills and decreasing problem behaviors in samples of Chinese-speaking people on the autism spectrum. Only Gu (2019) conducted experimental functional analysis of behavior; Gu (2019), however, did not provide sufficiently detailed descriptions of procedures and data to clearly demonstrate that the function of problem behavior was to obtain items and attention as they suggested. To determine the relationship between appropriate behaviors and communication resulting from PECS implementation, it will be important in future studies to conduct functional analysis to ensure that the function of problem behavior is related to obtaining tangible items or attention.

Three studies (23%) programmed for generalization of the outcomes of the PECS interventions but generalization to the natural environment was not evaluated (Hu & Lee, 2018; Qi & Zhao, 2018; Zheng & Li, 2017). Additional research should be conducted to explore how to integrate PECS interventions into daily routines with different communication partners across various settings where the child lives.

One study (8%) reported social validity concerning acceptability, feasibility, satisfaction, and helpfulness of the PECS intervention; only teachers or parents completed the social validity survey (Hu & Lee, 2018). Reichow (2011) suggests that reports of social validity should include at least four of the following: social importance, effectiveness, significance, satisfaction, context (natural or not), normative references for behavioral performance for typically developing children; as well, intervention should be implemented by persons who are typically in contact with the participant (e.g., parents, teachers). Hansen et al. (2017) suggested

that participants' actual peers should serve as indicators for assessing socially valid outcomes concerning the effectiveness of communication instruction. Future research should report on social validity from multiple dimensions that include a focus on factors such as the dependent variable, setting, and intervention procedure, and that gather information about the social validity of PECS from important social partners.

All our selected studies must be rated overall as weak in quality according to criteria set out by Reichow (2011). For a study to be rated as high quality in terms of participant characteristics, the study must report the participants' age and gender, the diagnostic instrument used to evaluate the participant, as well as other information including therapists' demographic information and secondary participants' information (e.g., peers), and participants' standardized test scores. None of the studies we selected reported interventionist information, and 12 of the 13 studies (92%) failed to report the participants' diagnostic instrument; therefore, the rating of all our selected studies in terms of participants' characteristics was unacceptable. Ten studies (77%) were rated as acceptable on the independent variable because they defined many elements of the independent variable even though they omitted specific details (Chen, 2019; Geng, 2019; Gu, 2019; Li & Du, 2016; Ling, 2020; Mao, 2017; Qi & Zhao, 2018; Qian, 2016; Zhang, 2015; Zheng & Li, 2017). Five studies (38%) were rated as unacceptable on the dependent variable because variables are defined with no operational precision (Chen, 2019; Geng, 2019; Gu, 2019; Qian, 2016; Zheng & Li, 2017). Zheng and Li (2017), for example, defined "non-appropriate mand" as the dependent variable but did not provide further information about the topography or intensity of the non-appropriate behavior. One study (8%) was rated unacceptable on baseline, visual analysis, and experimental control because it did not include a baseline for picture exchange (Hu & Lee, 2018). Two studies (15%) were rated unacceptable on visual analysis and experimental control because of the high overlap between baseline and intervention conditions on speech outcome (Hu & Lee, 2018; Li & Du, 2016). Six studies (46%) were rated as unacceptable on experimental control because they used ABC/AB designs that do not demonstrate a functional relation (Geng, 2019; Gu, 2019; Ling, 2020; Qi & Zhao, 2018; Qian, 2016; Zheng & Li, 2017).

Two explanations may be suggested for the overall weak rating of the selected studies. Because it was not twenty-first century that ABA was systematically disseminated in Mainland China, few Chinese researchers and journal editors understood SCD methodology (Huang et al., 2023). Secondly, Chinese researchers may be more likely to describe experimental variables and conditions loosely since their worldviews influenced by traditional Chinese culture tend to focus on general patterns (Huang et al., 2023). In the future, Chinese researchers should adhere to a rigorous methodology when using SCD to conduct studies.

Limitations

Limitations of this review must be considered when interpreting our findings. One limitation concerns the small number of studies selected for review ($n = 13$). We included only SCD studies. Expanding the inclusion criteria to include group designs might provide more evidence to support PECS as an effective intervention. A second limitation concerns the limited geographic area from which studies were selected; we did not include studies from Chinese-speaking areas such as Hong Kong and Taiwan that lie outside Mainland China. In addition, no other ethnic groups than the Han (the majority ethnic group in China) were included as participants in the studies; this limits the generalizability of the results of our review. A third limitation is that we selected and analyzed master's theses and conference papers that had not been peer-reviewed, which can affect the result of the quality evaluation.

Conclusion and Implications for Practice

To our knowledge, our study is the first systematic review of the quality of SCD studies of PECS interventions conducted in Mainland China. Although our review did not find sufficient evidence for judging the effectiveness of PECS for the Chinese-speaking samples on the autism spectrum, PECS nevertheless appears to be a promising intervention for improving communication and problem behavior for this population.

Some of the findings of our study have important clinical implications. Practitioners should conduct preference assessments to rank participants' preferred items, and these items should be tested daily before the beginning of an instructional session (Deleon et al., 2001). Prerequisite skills assessments should be conducted to ensure participants are ready for PECS intervention. Important prerequisite skills include hand movements such as holding, sticking, and tearing picture cards attached to the PECS book. Participants should also be able to match pictures to objects. For those who are unable to match, real or miniature objects or parts of objects can be used (Bondy & Frost, 1994). It is important to ensure that, before implementing PECS phase three, participants can discriminate among different pictures. Instruction in discrimination is recommended for those who do not have this critical skill (Bondy & Frost, 1994). Practitioners implementing PECS interventions should adhere to the PECS manual to achieve the desired effects. Finally, generalization should be incorporated as part of the interventions,

and practitioners could train parents to provide continuous opportunities for their children to use PECS in the natural environment in order to help them maintain acquired skills.

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Declarations

Conflict of Interest The authors declare no competing interests.

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