INT. J. OF DEVELOPMENTAL DISABILITIES, Vol. 59 No. 2, July, 2013, 95–107

Teaching non-verbal children with autistic disorder to read and write: a pilot study

SUZANNE GOH, AGNES WHITAKER, JUDITH FELDMAN, MARY BETH CULL, KEN HOYTE, MOLLY ALGERMISSEN, MAUREEN MCSWIGGAN-HARDIN, DAVIDA KUGELMASS and BRADLEY S. PETERSON

Columbia University Medical Center and New York State Psychiatric Institute, USA

Objectives: To assess the feasibility and effectiveness of an innovative curriculum designed to teach communicative receptive and expressive language to non-verbal children with autism through reading and writing.

Methods: Randomized, controlled clinical trial of 18 children aged 5–13 years with autistic disorder and functional spoken language limited to single words, holophrases, or over-learned phrases. The treatment group ($n=9$; mean age: 7·1 years; three female) received 9–11 months of one-to-one instruction in reading and writing. The control group ($n=9$; mean age: 8·6 years; two female) received teaching that matched the literacy curriculum in all features of administration and organization, but taught number recognition, addition, and subtraction. Before and after the intervention, participants were given criterion-referenced tests to assess their skills in the knowledge domains taught in the treatment and control interventions.

Results: Five literacy participants and four control participants completed the study. Both groups showed greater improvement on the skills in which they had been trained, compared to the other group: Hotelling's Trace=0·66, $F(1,7)=4·63$, $P=0·034$ (one-tailed), $\eta_P^2=0·40$. On the literacy criterion-referenced test, the literacy group showed significant improvement: paired $t(4)=2·40$, $P=0·037$ (one-tailed); the control group did not ($P>0·10$).

Discussion: Literacy instruction may be a route to language acquisition for some children with autism who have little or no functional spoken language.

KEYWORDS autism, language, literacy, non-verbal, randomized controlled trial

 DOI 10.1179/2047387713Y.0000000014

Introduction

Communication deficits are a core feature of autism spectrum disorders (ASDs), and an estimated 30–50% of individuals with ASD never develop functional speech (Tager-Flusberg, 1996). While the neural basis for the speech-language deficit in ASD is not well understood, multiple factors across cognitive, motor, and sensory domains are likely to play a role. These may include oral-motor dyspraxia, intellectual disability, impaired social cognition, and disrupted auditory processing.

The Interagency Autism Coordinating Committee (2005) has prioritized the development of more effective treatments for this group of children, with the goal of achieving functional speech in 90% of school-age children with ASD. Reaching this goal will require the development and implementation of language programs that are more effective than those currently available. Language interventions for children with ASD typically begin by teaching spoken language. Children are taught to repeat single words — generally nouns, such as apple, cookie, or dog — or labels for colours, sizes, shapes, and letters (Lovaas, 1987; Schopler *et al.*, 1980). The emphasis on labelling of nouns and the use of over-learned phrases with nouns, such as 'I want *X*' or 'I see *X*', is a common feature of language curricula, and for many children with ASD, spontaneous speech does not progress beyond these skills. At present, school-age children with ASD who do not have functional speech generally continue with discrete trial learning. Children with ASD who do not have functional language may be at increased risk for aggression and self-injury (Dominick *et al.*, 2007).

Functional speech is clearly an important goal for children with ASD; however, other routes also exist for building more extensive and effective communication. In typically-developing children, spoken language emerges well before written language, and conventional wisdom holds that children must learn to speak before they can read (Mirenda, 2003). For children with ASD, this may not be the case for several reasons. First, auditory processing abilities are frequently disrupted in ASD, whereas visual perceptual abilities may be normal or even enhanced (Marco *et al.*, 2011; Samson *et al.*, 2011). Second, hyperlexia — the precocious ability to identify words despite impairments in reading comprehension and general cognitive functioning — is a condition associated more frequently with ASD than other developmental disorders, suggesting that, for at least some individuals with ASD, the functioning of neural networks that underlie the visual decoding of words may be enhanced (Grigorenko *et al.*, 2003). Third, case reports provide striking examples in which some individuals with ASD read and write meaningfully despite the absence of spoken language (Eastham and Grice, 1992; Fleischmann and Fleischmann, 2012).

To our knowledge, no reading program has been developed and widely disseminated to address the needs of non-verbal children with ASD. We undertook a small randomized, controlled trial of an innovative curriculum designed to teach communicative receptive and expressive language to non-verbal children with ASD through reading and writing. This pilot study aimed to assess the feasibility and effectiveness of the literacy curriculum in both home and school settings.

Methods

Participants

Eighteen children with autistic disorder aged 5–13 years participated in the study. They were recruited from child psychiatry clinics, special education schools, and databases of research participants for other studies of ASD at Columbia University Medical Center. The study was approved by the Institutional Review Board of the New York State Psychiatric Institute. The parents of all children gave written informed consent before their participation, and all procedures were conducted according to the approved protocol.

Each participant had a diagnostic evaluation performed by an expert clinician that included the Autism Diagnostic Interview-Revised and the Autism Diagnostic Observation Schedule Module 1 (Lord *et al.*, 2000). All ASD participants met criteria for a diagnosis of autistic disorder based on both of these instruments and met DSM-IV-TR criteria for autistic disorder.

All children met the following additional inclusion criteria: (1) English-speaking parents; (2) functional spoken language limited to single words, holophrases, or over-learned phrases; (3) capable of sitting for 5 minutes with an instructor without uncontrollable disruptive behaviours; and (4) no visual or hearing impairment.

Study design

Each child was randomly assigned to the treatment or control group. Trained instructors carried out manualized one-to-one sessions lasting approximately 1 hour five times per week for 9–11 months. All children continued to attend school, where they received typical instruction according to their Individualized Education Plans.

Teaching sessions were administered either at home or in school according to the preference of school personnel. If school administrators agreed to have the sessions administered at school, then the child's school teacher was trained in the program and served as the child's instructor. Otherwise, the program took place in the child's home and was administered by a trained tutor after regular school hours.

A key decision in the design of the study was whether to have doctoral level clinicians administer the sessions, or to employ personnel with less specialized training. Before the study, the literacy curriculum had only been administered by doctoral level clinicians at our clinic in close collaboration with a child's parent. Because a key goal of the pilot study was to determine the feasibility of a larger scale clinical trial, the decision was made to train a team of staff to administer the program with the children. The instructors were recruited by word-of-mouth and by poster advertisements on university campuses. In total 12 tutors and 5 school teachers served as instructors for the study. All had bachelor's degrees or master's degrees at the time of the study.

Intervention

The literacy curriculum used in this study is an innovative program designed by Dr Marion Blank, developmental psychologist and author of *The Reading Remedy*

(Blank and Bruskin, 1982; Blank, 2006; Blank and Cull, 2010). The program teaches the decoding, spelling, comprehension, and expressive use (within sentences) of 100 words, including nouns, verbs, and non-content words. The teaching utilizes computer software along with paper and pencil exercises. As new words are introduced, they are immediately linked to words previously learned so that the child can steadily create meaningful sentences of greater complexity.

The literacy curriculum has grown out of extensive experience at our tertiary care referral clinic with severely affected, non-speaking children with autistic disorder. The program is designed specifically to address the unique needs of this group, which has high rates of comorbid intellectual disability, disruptive behaviours, and motor impairments. Because of these comorbidities, specific techniques of administration are critical to the teaching. Key features of administration include the following:

1. location and workspace. All sessions were carried out in a quiet room or other secluded area with no TV or other distractions. The workspace was free of clutter and there was no food or drink on or near the table. One break could be offered during the session, but the break took place away from the work area. The work area was never located in the child's bedroom. During the teaching sessions, the instructor sat next to the child at a table or desk. The child sat in a firm chair with his or her feet touching the ground;
2. managing motor impairment and disruptive behaviours. All of the activities in the program require some level of motor skill, which can be challenging for many children with ASD (Dziuk *et al.*, 2007; MacNeil and Mostofsky, 2012). To overcome these difficulties during the initial period of the teaching, tutors provided hand stabilization. Stabilizing the child's hand meant that the tutor held the child's hand at the palm or wrist but did not move it. This technique differs from the commonly used 'hand over hand' technique where the instructor actively moves the child's hand. The purpose of providing hand stabilization was two-fold: (1) to lessen some of the motor demands of the task so the child could concentrate on the language demands and (2) to prevent the child from making inappropriate, distracting movements. Hand stabilization was faded over time as the children became more skilled;
3. instructor's demeanor. The instructor's demeanor was another critical aspect of administration. During the teaching session, the tutor aimed for a demeanor described as 'calm control'. All spoken language and all actions were done in a clear, direct, and deliberate manner. There were no rewards such as food, toys, or 'high-fives'. Correct responses were acknowledged solely with comments such as 'good' or 'nice job', and these were not offered for every correct response. Aside from this, the tutor only said what was specified in each item in the workbooks. No other spoken language was used during the teaching session.

Key features of the literacy curriculum itself include the following:

1. focus on teaching key pre-verbal skills. For literacy, a critical pre-reading skill is visual sequencing (the counterpart in spoken language is auditory

temporal sequencing). Skill in visual sequencing allows a reader to recognize that 'dog' is a word, whereas 'dgo' is not, or that, 'The boy is sitting' is a sentence, whereas 'Boy is the sitting' is not. The literacy curriculum begins by presenting children with a sequence of letters (up to four letters), which they have to process and reproduce, sometimes from memory;

2. focus on select nouns (animate beings) and relevant verbs (actions that the beings can perform). Noun–verb pairings are at the core of any meaningful language system and are the essential form that all languages have in common (Sapir, 1921). In language programs for ASD, nouns and verbs are often taught separately. In our curriculum, these words are not presented as individual disconnected elements, but instead are meaningfully linked in ways that reveal their properties. To achieve this linkage, the nouns must be capable of performing the actions represented by the verbs to which they are attached (e.g. birds fly, kids run, bugs crawl, fish swim, etc.) Thus, the nouns must represent animate beings, since they are the ones that perform actions. Inanimate objects generally do not meet this criterion, except in select cases (e.g. planes fly). This approach contrasts with that of typical language programs which start off focusing on inanimate beings or features that lack animate properties (e.g. foods, shapes, sizes, colours, etc.);
3. inclusion of 'non-content' words. Effective use of language (both spoken and written) requires a range of non-content words and suffixes that are often excluded from mainstream autism curricula. They include function words, such as the, is, was, and who, and suffixes that impart grammatical information, such as plural and tense markers. These linguistic components, also termed grammatical morphemes, occupy more than 50% of the words spoken in conversation or written on a page. They are essential to sentence structure and the expression of time relations (e.g. is versus was, do versus did, etc.) (Blank and Bruskin, 1982; Blank and Cull, 2010);
4. providing an algorithm to enable children to differentiate among, and respond effectively to, a range of question forms. Children were taught to answer (via writing) questions referring to the past (e.g. What were the kids doing?), the future (e.g. What are the birds going to do?), negation (e.g. Which one is not sitting?), and possession (e.g. Who has a hat?);
5. the use of language to express ideas beyond the immediate present. Children were taught to read, write, and comprehend sentences involving the past (e.g. The kids were sitting), the future (e.g. The birds are going to fly), negation (e.g. This cat is not sitting), and possession (e.g. The girl has a hat).

The control curriculum was designed to match the literacy curriculum in individualized attention, organization, and techniques of administration. The only major difference was the content of instruction. Children in the control condition were taught to recognize, understand, add, and subtract the numbers 0–15.

Criterion-Referenced and Standardized Assessments

Criterion-referenced tests are the preferred format used in schools to assess whether students have learned material taught to them over a preceding interval of time. This format (rather than a norm-referenced test) was deemed to be the best instrument to assess whether children had learned the skills taught to them during the study.

Before and after the intervention, the children were administered criterion-referenced tests to assess their skills in the knowledge domains taught in the treatment and control conditions. The literacy test included items testing skills in reading and writing. The control test included items testing skills in number recognition, understanding, and manipulation (e.g. addition and subtraction). Test items were designed to assess the skills and knowledge domains involved in the literacy and control interventions but did not use items that were explicitly taught during the intervention. Sets of items from the two tests were intermixed and presented in a single-test format, so that both groups were tested in the domain in which they had been instructed and also in the domain in which they had received no instruction. To protect against 'carry-over' from pre- to post-test, two versions of the test protocol were prepared, using alternative sets of items; each child received one version for the pre-test and the alternative version for the post-test (with the version used on pre-test randomized over participants). The criterion-referenced tests were each assigned a total score based on the number of points accrued across all items.

To guard against unintentional coaching of responses, the test administrator was someone who had not been involved in any other aspect of the study and who was blinded to treatment assignment. On occasion, hand stabilization was needed during the testing sessions to aid the child in fine motor control and behaviour control. In such cases, the individual providing hand stabilization was blocked from viewing the test items.

Participants were also assessed with a non-verbal intelligence test (Leiter International Performance Scale-Revised) within one month before the start of the intervention and within 2 weeks following completion of the intervention.

Data analysis

Groups were compared on background demographic variables, clinical characteristics, and test scores using independent group *t*-tests for continuous measures and Chi-square tests for categorical ones. Because of the small number of participants per group, a 0·10 criterion for significance was used for these tests. For tests of pre-stated hypotheses, a one-tailed test was used with a 0·05 criterion.

To address the principal hypothesis of the study — that the literacy group would show greater improvement on the literacy test than the control group — scores on the criterion-referenced tests were subjected to a multivariate repeated measures analysis (MANOVA) having two repeated-measures factors — time (pre-test versus post-test) and test (literacy versus control) — and one between-subjects factor — intervention (literacy versus control). The expectation here was that there would be a significant three-way interaction: group by test by time, reflecting greater pre- to post-training gains by the literacy group on the literacy test

compared to the control group and *vice versa*. Follow-up tests examined improvements on each test individually for each group using paired *t*-tests.

Results

The demographic and clinical characteristics of the participants are provided (Table 1). The treatment and control groups did not differ significantly by age, sex, or non-verbal intelligence test score (NVIQ) ($P>0{\cdot}1$).

The first aim of this pilot study was to determine the feasibility of program administration in different instructional settings. Of the 18 participants in the study, nine completed the intervention. The completers did not differ significantly from the non-completers in age, sex, or NVIQ ($P>0{\cdot}1$). Of the nine completers, seven received instruction at home, while two received instruction at school. By contrast, of the nine non-completers, eight received instruction in the school setting and one at home.

Substantial difficulties were encountered in administering the program in schools, including frequent cancellation of sessions due to classroom scheduling conflicts. Teachers reported that they were engaged in other pressing matters at the time set aside for the teaching session and that the sessions were lower priority than other obligations they saw for themselves, such as implementing the standard

TABLE 1

PARTICIPANT CHARACTERISTICS

Pt #	Age (years)	Sex	Group	Pre-intervention Leiter Intelligence test score	Teaching environment	Study completion
1	5·7	M	Literacy	63	Home	Yes
2	7·4	M	Control	62	School	No
3	10·0	M	Control	65	School	Yes
4	7·8	F	Literacy	58	School	No
5	7·1	M	Literacy	54	School	Yes
6	7·9	M	Control	36	Home	No
7	7·9	M	Literacy	50	Home	Yes
8	9·9	F	Control	60	Home	Yes
9	8·5	M	Control	40	Home	Yes
10	6·9	M	Literacy	60	School	No
11	6·7	M	Control	70	School	No
12	7·4	F	Control	77	School	No
13	7·4	M	Literacy	65	School	No
14	6·1	M	Control	70	School	No
15	6·6	F	Literacy	42	School	No
16	6·2	M	Literacy	83	Home	Yes
17	13·6	M	Control	40	Home	Yes
18	8·1	F	Literacy	52	Home	Yes

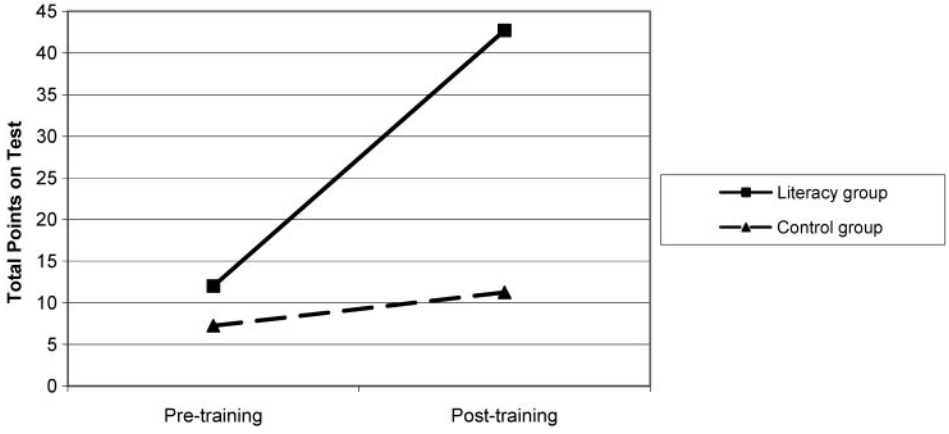

FIGURE 1 Group performance pre-training and post-training on the literacy test (training period ranged from 9–11 months).

classroom curriculum and managing disruptive behaviours of other children in the class. The tutors who conducted the program in the children's homes found few obstacles to program implementation. The home participants did not differ from the school participants in age, sex, or NVIQ ($P>0{\cdot}1$).

The second aim of this pilot study was to determine whether the literacy group would show greater improvement on the literacy test compared to the control group. Indeed, this was the case (Fig. 1).

Three literacy participants showed marked improvement in literacy test scores, while two showed little or no change (Fig. 2).

The control participants showed little or no improvement on the literacy test.

The MANOVA showed a significant three-way interaction [Hotelling's Trace$=0{\cdot}66$, $F(1,7)=4{\cdot}63$, $P=0{\cdot}034$ (one-tailed), $\eta_P^2=0{\cdot}40$], reflecting the fact that both groups showed greater improvement on the skills in which they had been trained, compared to the other group. On the literacy criterion-referenced test, the literacy group showed significant improvement pre- to post-training [paired $t(4)=2{\cdot}40$, $P=0{\cdot}037$ (one-tailed)]; the control group did not ($P>0{\cdot}10$).

Participants were assessed with the Leiter International Performance Scale-Revised before and after the intervention. We hypothesized that there would be no change in NVIQ pre- to post-training in either group. However, the literacy group did show overall improvement in NVIQ and this approached statistical significance [$t(7)=2{\cdot}28$, $P=0{\cdot}085$ (two-tailed)] (Table 2).

Discussion

The aim of this study was to assess the feasibility and effectiveness of an innovative curriculum to teach reading and writing to non-verbal children with autistic disorder. The results of this pilot study suggest that the acquisition of reading and

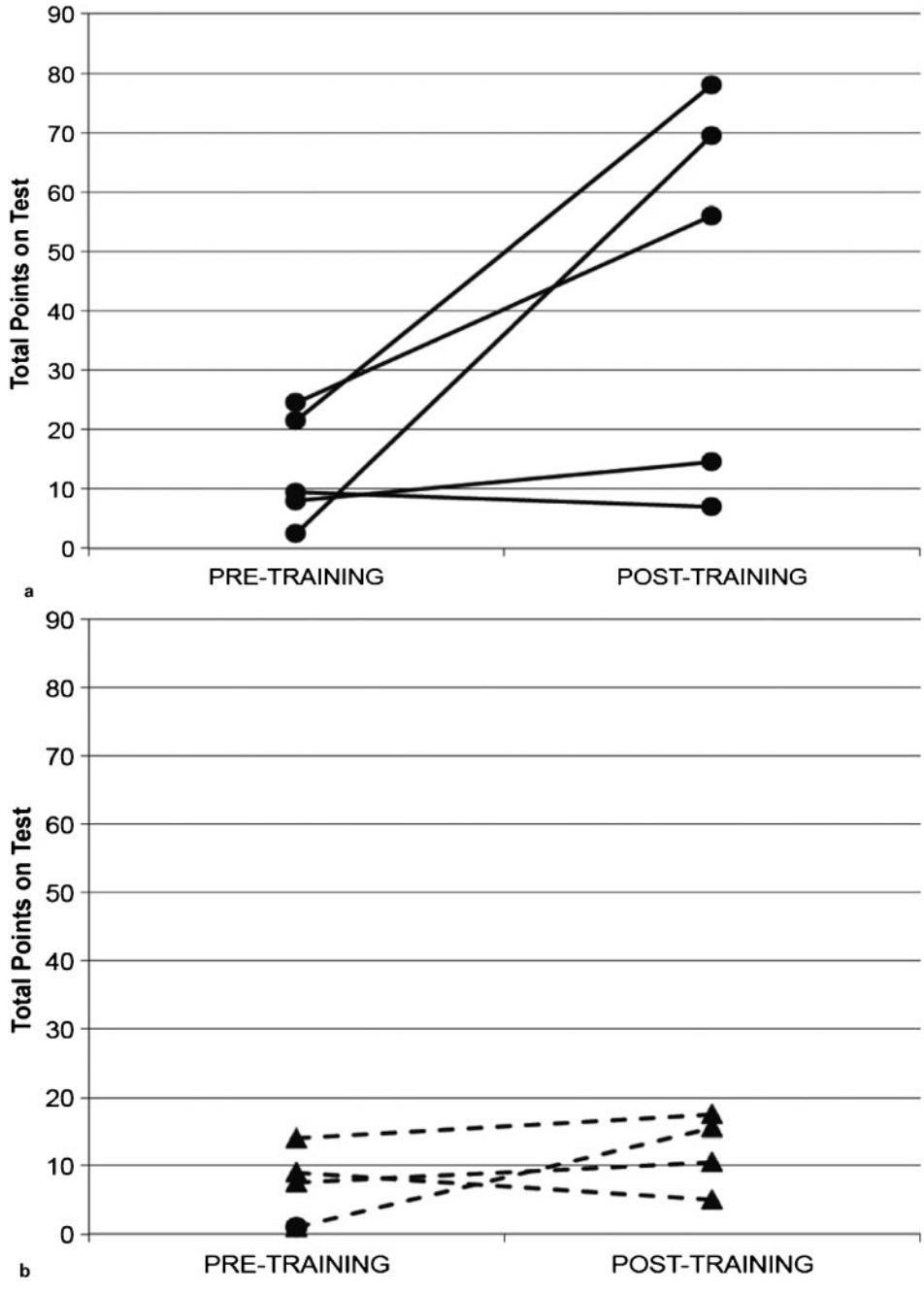

FIGURE 2 Individual literacy test scores pre- and post-training: (a) literacy group; (b) control group.

TABLE 2

PRE- AND POST-TRAINING SCORES ON THE LEITER INTERNATIONAL PERFORMANCE SCALE-REVISED FOR THE STUDY COMPLETERS

Pt #	Group	Intelligence test score pre-training	Intelligence test score post-training
1	Literacy	63	73
3	Control	65	60
5	Literacy	54	67
7	Literacy	50	46
8	Control	60	46
9	Control	40	42
16	Literacy	83	89
17	Control	40	ND*
18	Literacy	52	60

NOTE: *Not done due to patient's cancellation of testing session.

writing skills may be possible in some of the most severely affected children with ASD even in the absence of functional speech.

Before the study, the literacy curriculum had been administered on a clinical basis at our tertiary care centre by doctoral level faculty with a high level of parent involvement. The unique needs of this patient population made it unclear whether expansion of the program could be achieved by training personnel and offering the program directly in schools. The high non-completion rate in schools is informative because it draws attention to the challenges of administering an unfamiliar curriculum in an established classroom environment. Moreover, disruptive behaviours are common among the children in these classrooms, and teachers face a myriad of competing demands. This pilot study provides important insights that will help guide the design of future clinical trials.

Despite the high non-completion rate, the study showed significant improvement in reading and writing skills in the literacy group. The marked improvement seen in three out of the five literacy participants and little or no improvement seen in two of the participants suggests that a subset of non-verbal children with ASD may be able to learn language through reading and writing, while a subset may not. Improvement in NVIQ in the literacy group was not expected and suggests that access to language via reading and writing may improve some children's ability to acquire skills in other cognitive domains.

Advances in our understanding of sensory processing disturbances in ASD provide a compelling rationale for why literacy may be possible in children with ASD who do not speak. The comprehension and production of spoken language rely on a host of skills that are known to be impaired in ASD, such as auditory processing, temporal sequencing, and oral-motor praxis. In contrast, written language relies to a great extent on visual perceptual abilities — namely, the visual decoding of words, which is known to be enhanced in many individuals with ASD (Marco *et al.*, 2011; Samson *et al.*, 2011; Grigorenko *et al.*, 2003). The widespread availability of computers provides an additional support for literacy, since typing

is a mode of language production that does not require as great a degree of fine motor control as speech production or handwriting.

Research into alternative modes of communication for non-verbal children with ASD has centred largely upon Picture Exchange Communication Systems (PECS) and sign language. These are important modalities for children with language disorders; however, research in both these realms suggests that these forms of communication are not likely to accelerate speech development or to provide entry into a fully functional language system (Paul, 2008; Preston and Carter, 2009; Lord and McGee, 2002).

By contrast, literacy — the ability to read and write — provides an alternative mode of communication with the potential to support a fully functional language system. Relatively little is known about literacy skills in non-speaking children with ASD, in part because literacy has not been deemed possible in this group (Mirenda, 2003; Browder and Spooner, 2006). To the limited extent that literacy instruction is incorporated into language intervention, its focus has been on basic vocabulary and sight word instruction (Houston and Torgeson, 2004; Browder *et al.*, 2006). Traditional literacy training also tends to begin with instruction in phonemic awareness — often without pictures or meaningful context — making it challenging for students with ASD to demonstrate mastery. Literacy instruction for students with ASD is often abandoned prematurely because they struggle to demonstrate mastery of phonemic awareness (Mirenda, 2003).

The literacy curriculum used in this study does not rely on phonemic awareness and has several additional features that differ from traditional curricula, including a focus on teaching non-content words. The importance of non-content words is often not recognized in language instruction programs (Blank and Bruskin, 1982). Instead, they are viewed as sources of confusion, and, therefore, are intentionally omitted. An instructor might say 'touch same' or 'show me sitting' rather than 'touch the one that is the same' or 'show me the kid who is sitting'. Although these efforts are well-intentioned and are meant to simplify language, their consequence is the neglect of an aspect of language that is essential for communication. Research shows that the mastery of non-content words poses a particular challenge for children with ASD (Eigsti *et al.*, 2007).

Two key obstacles stand in the way of successful literacy training in children with ASD. First, disruptive behaviours can interfere with any sustained task that requires focused attention. Our literacy curriculum employs several techniques to manage disruptive behaviours and these are central to the success of the curriculum (described in the section on 'Methods'). Second, motor impairments must be recognized and appropriate support and remediation provided. An important technique in our literacy program is the use of hand stabilization. When using techniques like hand stabilization, the instructor must be exceedingly vigilant to avoid unintentionally moving the child's hand. It is also imperative that the stabilization be faded over time once the child's fine motor skills improve so that the child can demonstrate independence.

The preliminary findings of this pilot study suggest that in the field of language intervention for non-verbal children with ASD, literacy should be among the alternative modes of communication that is offered. The heterogeneity of the ASD

phenotype demands a diverse set of treatment approaches to language development, and literacy training provides one potential route to a functional language system for the children in greatest need.

Acknowledgements

This study received financial support from Autism Speaks, the Language Learning Small Grants Program, the Suzanne Crosby Murphy Endowment at Columbia University, Arlene and Mitchel Maidman, and Burt and Lynne Manning.

References

Blank, M. 2006. The reading remedy: six essential skills that will turn your child into a reader; San Francisco, CA, Jossey Bass.

Blank, M. and Bruskin, C. 1982. Sentences and non-content words: missing ingredients in reading instruction, *Ann. Dyslexia*, **32**, (1), 103–121.

Blank, M. and Cull, M. B. 2010. Language and children with autism: the two worlds underlying verbal communication, in Language in the real world: an introduction to linguistics, (ed. S. Behrens and J. Parker), 329–345; New York, Routledge.

Browder, D. M. and Spooner, F. 2006. Teaching language arts, math, science to students with autism; Baltimore, MD, Paul H. Brookes Publishing Co.

Browder, D. M., Wakeman, S. Y., Spooner, F., Ahlgrim-Delzell, L. and Algozzine, B. 2006. Research on reading instruction for individuals with significant cognitive disabilities, *Except. Child.*, **72**, 392–408.

Dominick, K. C., Davis, N. O., Lainhart, J., Tager-Flusberg, H. and Folstein, S. 2007. Atypical behaviors in children with autism and children with a history of language impairment, *Res. Dev. Disabil.*, **28**, (2), 145–162.

Dziuk, M. A., Gidley Larson, J. C., Apostu, A., Mahone, E. M., Denckla, M. B. and Mostofsky, S. H. 2007. Dyspraxia in autism: association with motor, social, and communicative deficits, *Dev. Med. Child Neurol.*, **49**, (10), 734–739.

Eastham, M. and Grice, A. 1992. Silent words: a biography; Ottawa, Ont., Oliver-Pate.

Eigsti, I. M., Bennetto, L. and Dadlani, M. B. 2007. Beyond pragmatics: morphosyntactic development in autism, *J. Autism Dev. Disord.*, **37**, (6), 1007–1023.

Fleischmann, A. and Fleischmann, C. 2012. Carly's voice; New York, Touchstone.

Grigorenko, E., Klin, A. and Volkmar, F. 2003. Annotation: hyperlexia: disability or superability?, *J. Child Psychol. Psychiatry*, **44**, (8), 1079–1091.

Houston, D. and Torgesen, J. 2004. Teaching students with moderate disabilities to read: insights from research; Tallahassee, FL, Florida Department of Education, Bureau of Instructional Support and Community Services.

Interagency Autism Coordinating Committee. 2005. IACC Autism Spectrum Disorder (ASD) Services Roadmap, Resource document, US Department of Health and Human Services, http://iacc.hhs.gov/publications/2005/services-subcommittee-report-may16.shtml (accessed 16 May 2012).

Lord, C., Rutter, M. and Le Couteur, A. 1994. Autism Diagnostic Interview-Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders, *J. Autism Dev. Disord.*, **24**, (5), 659–685.

Lord, C., Risi, S., Lambrecht, L., Cook, E. H. Jr, Leventhal, B. L., DiLavore, P. C., Pickles, A. and Rutter, M. 2000. The autism diagnostic observation schedule-generic: a standard measure of social and communication deficits associated with the spectrum of autism, *J. Autism Dev. Disord.*, **30**, (3), 205–234.

Lord, C. and McGee, J. 2002. Educating children with autism; Washington, DC, National Research Council.

Lovaas, O. I. 1987. Behavioral treatment and normal educational and intellectual functioning in young autistic children, *J. Consult. Clin. Psychol.*, **55**, (1), 3–9.

MacNeil, L. K. and Mostofsky, S. H. 2012. Specificity of dyspraxia in children with autism, *Neuropsychology* **26**, (2), 165–171.

Marco, E. J., Hinkley, L. B. N., Hill, S. S. and Nagarajan, S. S. 2011. Sensory processing in autism: a review of neurophysiologic findings, *Pediatr. Res.*, **69**, (5 Pt 2), 48R–54R.

Mirenda, P. 2003. 'He's not really a reader…': perspectives on supporting literacy development in individuals with autism, *Top. Lang. Disord.*, **23**, (4), 271–282.

Paul, R. 2008. Interventions to improve communication in autism, *Child Adolesc. Psychiatry Clin. N. Am.*, **17**, (4), 835–856.

Preston, D. and Carter, M. 2009. A review of the efficacy of the picture exchange communication system intervention, *J. Autism Dev. Disord.*, **39**, (10), 1471–1486.

Samson, F., Mottron, L., Soulieres, I. and Zeffiro, T. A. 2011. Enhanced visual functioning in autism: an ALE meta-analysis, *Hum. Brain Mapp.*, **33**, (7), 1553–81.

Sapir, E. 1921. Language: an introduction to the study of speech; New York, Harcourt, Brace and Company.

Schopler, E., Reichler, R. J. and Lansing, M. D. 1980. Individualized assessment and treatment for autistic and developmentally disabled children; Baltimore, MD, University Park Press.

Tager-Flusberg, H. 1996. Current theory and research on language and communication in autism, *J. Autism Dev. Disord.*, **26**, (2), 169–172.

Notes on contributor

Correspondence to: S. Goh, Columbia University Medical Center and New York State Psychiatric Institute, 1051 Riverside Drive, New York, New York 10032, USA. Email: suzgoh@gmail.com