

Early phonological awareness and reading skills in children with Down syndrome

Esther J. Kennedy¹ and Mark C. Flynn²

¹Ministry of Education: Inclusive Services Group, Invercargill, New Zealand

²Department of Speech and Language Therapy, University of Canterbury, Christchurch, New Zealand

Abstract – Increasingly, children with Down syndrome receive literacy instruction with the expectation of acquiring functional reading skills. Unfortunately, little is known about the processes underlying literacy skills in this special population. Phonological awareness contributes to literacy development in typically developing children, however, there is inconclusive evidence about these skills in younger children with Down syndrome. 9 children with Down syndrome (5;6 – 8;10 years) participated in this investigation. Due to the paucity of standardised phonological awareness measures for children with special needs, in particular children with Down syndrome, a variety of tasks were adapted from the literature. The assessment battery examined the skills of phonological awareness, literacy, speech production, expressive language, hearing acuity, speech perception, and auditory-visual memory. The results suggest that children with Down syndrome are at risk for reading acquisition difficulties due to reduced phonological awareness skills. These deficits are in addition to delays caused by reduced cognitive skills. Only one of the participants was able to demonstrate rhyme awareness, which may have been due to task effects. Written word recognition ability was correlated with tests of phonemic awareness, and error analysis of the spelling and non-word reading tasks suggested grapheme-phoneme connections deficits. Further research is needed to determine the best methods of assessment and intervention for phonological awareness in children with Down syndrome.

Keywords: Down syndrome, phonological awareness, reading

Mounting evidence suggests that children with Down syndrome display unique developmental characteristics in the areas of speech, language, memory, and auditory processing relative to other children with cognitive impairment (Chapman, Seung, Schwartz & Kay-Raining Bird, 1998; Marcell & Cohen, 1992; Miller, Leddy & Leavitt, 1999). Despite an increase in the number of children with Down syndrome learning to read, little is known about the skills that underlie literacy acquisition for these children (Cossu, Rossini & Marshall, 1993; Fowler, Doherty & Boynton, 1995). Therefore, it is necessary to investigate literacy development in children with Down syndrome, to determine if the distinct profiles of development in other areas lead to atypical literacy acquisition.

Phonological awareness refers to the broad range of skills in the awareness and manipulation of sound structures at the syllable, onset/rime and phonemic level (e.g. counting of syllables, rhyming and isolating initial phonemes).

Acquisition of these skills has been found to be essential to the development of literacy. Measurement of phonological awareness understanding have become crucial because phonological awareness abilities consistently predict reading ability in typically developing children (Ehri, 1999; Lonigan, Burgess, Anthony & Barker, 1998; Wagner, Torgesen & Rashotte, 1994; Wood & Terrell, 1998) and current models of literacy acquisition emphasise the phonological route in word decoding (Ehri, 1999). Recent research into the relationship between phonological processing and reading in typically developing children emphasises the reciprocal nature of influence between learning to read and phonological awareness (Burgess & Lonigan, 1998; Wagner et al., 1997). Only recently have researchers begun to investigate the literacy acquisition and phonological awareness skills of children with Down syndrome, in order to support methods of reading instruction or remediation of literacy difficulties (Byrne, Buckley, MacDonald &

Bird, 1995; Cossu et al., 1993; Cupples & Iacono, 2000; Fletcher & Buckley, 2002; Fowler et al., 1995; Kay-Raining Bird, Cleave & McConnell, 2000).

The work of Cossu et al. (1993) and Evans (1994) demonstrated that it is difficult to quantify phonological processing skills in children with Down syndrome using tasks designed for use with typically developing, literate children. These tasks yielded more useful results when used to investigate the phonological awareness skills of young adults with Down syndrome (Fowler et al., 1995). Assessment variables in phonological awareness tasks should be carefully considered with this population, so that the tasks specifically measure phonological awareness skills, without being unnecessarily complicated by general cognitive skill level. Kay-Raining Bird et al. (2000) demonstrated that using phonological awareness tasks designed for measuring phonological awareness in pre-school children yields valuable information about phonological awareness development in children with Down syndrome. Similarly, Cupples and Iacono (2000), followed by Fletcher and Buckley (2002), examined the phonological awareness of school-aged children with tasks specifically designed for children with Down syndrome. The current study adds further information to this research through an evaluation of primary school children who have undergone at least six months of formal literacy instruction.

When investigating phonological awareness in children with Down syndrome the importance of hearing and short-term auditory memory should not be ignored. Hearing impairment is prevalent in people with Down syndrome (Davies, 1985; Iino, Imamura, Harigai & Tanaka, 1999; Marcell, 1995; Miller, 1987; Pueschel & Sustrova, 1996). Hence, it is no surprise that individuals with Down syndrome frequently present with poorer speech perception and auditory processing skills (Marcell, 1995), especially in the area of auditory short-term memory (Bower & Hayes, 1994; Byrne et al., 1995; Marcell & Weeks, 1988; Varnhagen, Das & Varnhagen, 1987). Hearing loss always brings concerns for speech and language development (Miller, 1987), and consequently phonological awareness skills and literacy acquisition. If a child is unable to perceive and process all the speech sounds then it will be more difficult for them to form accurate letter-sound (grapheme-phoneme) associations, and learn to phonologically recode (Buckley, Bird & Byrne, 1996).

Literacy acquisition in children with Down syndrome is likely to be affected by underlying impairments in hearing, speech, language and memory systems. An area of literacy acquisition to receive attention in the research literature recently is the role of phonological awareness (Cupples & Iacono, 2000; Fletcher & Buckley, 2002). This study sought to determine the relationship between phonological awareness and literacy acquisition in children with Down syndrome. It was hypothesised that the children with Down syndrome with better phonological awareness would also score higher in literacy measures.

Method

Participants

Participants were recruited through the Canterbury branch of the Down Syndrome Association of New Zealand. Nine children with Down syndrome (5;5 – 8;10 years) participated in this project. The criteria for acceptance into the project were; (1) diagnosis of Down syndrome (Trisomy 21); (2) at least 5;0 years old; (3) at least six months exposure to formal literacy instruction at a mainstream school; (4) normal or corrected vision. The average time spent at school, at the time of entrance into the project, was 21.3 months (range: 6 – 40 months). The predominant reading instruction philosophy in New Zealand is based around “whole language” with a focus on extracting meaning from text. Thus, the children who were attending mainstream primary schools had received little, if any, direct phonologically-based literacy instruction.

Assessment procedures

Hearing and Speech Perception: All of the children were under management of an audiologist and had a complete audiological assessment immediately prior to the study. The pure-tone audiometry results indicated a mild degree of hearing loss for five of the nine participants (Pure Tone Average > 15 dBHL in the best ear) at the time of testing. In order to overcome any effects of conductive hearing impairment a Phonic Ear Easy Listener Sound Field System was used. This system consists of a microphone (worn by the investigator) and loud speakers strategically placed around the room. Thus providing an optimal auditory signal and maximising the participant’s ability to accurately perceive subtle phonemic distinctions (Bennetts & Flynn, 2002; Palmer, 1997). Speech perception testing was conducted using the Kendall Toy Test (Dale, 1962) with the lowest dBA production correctly identified by the participant was noted for each toy. The average across the ten toys was calculated and this became the speech perception score.

Short-Term Memory: Short-term auditory memory was assessed using a task based on that described by Broadley and MacDonald (1993). Briefly, this involved sets of semantically unrelated pictures of one, two and three syllables. The pictures were placed in a line in front of the participant, and named from left to right, once by the investigator, and twice by the participant. The pictures were then turned over in order from left to right, and the participant was required to recall the pictures on the up-turned cards in order from left to right. Audio-visual short-term memory span was taken to be the length of list which the participant correctly recalled at least three out of the five trials.

Speech Production: Speech production was assessed using the *Assessment of Phonological Processes-Revised* (APP-R) (Hodson, 1986), and *PROPHet*, (Long & Schroeder, 1999). This enabled the calculation of a Percentage Consonants Correct (PCC) from a list of 106 single words.

Expressive Language: A Mean Length of Utterance (MLU) (Miller, 1981) in morphemes was calculated from a conversational language sample of between 50-100 complete and intelligible utterances.

Reading: The Burt Word Reading Test – New Zealand Revision (Gilmore, Croft & Reid, 1981) was used to assess written word recognition. When the child was unintelligible while reading from the sheet, a list of the words the child could consistently read correctly was requested from the child's teacher and these were compared to the test list to gain a score on this test.

Phonological awareness: A series of measures were used to assess the phonological processing skills of the children. Those that were selected and adapted for this research project had been used successfully to demonstrate emergence of phonological awareness skills in preschool children (Burt, Holm & Dodd, 1999; Gillon, 2000; Larrivee & Catts, 1999; Maclean, Bryant & Bradley, 1987). The tasks required the participant to respond non-verbally, thus overcoming speech intelligibility problems, and where possible, tests were incorporated into game-like formats, using pictures as support for auditory memory and to increase motivation. Vocabulary of the practice and test items was controlled, so that items were culturally familiar and age appropriate, and the tasks were designed to require no more than approximately seven minutes administration time, so as to maximise attention, concentration and motivation of the participants.

Rhyme detection: The rhyme detection task was based on the measure developed by MacLean, Bryant and Bradley (1987), which was designed to produce a measure of the ability to recognise common rhyme units across words. The participant was presented with three pictured words, two of which rhymed (e.g., fish, dish, ball; dog, book, hook). The investigator named the pictures, and the participant was asked to cross out the one that did not rhyme. The task consisted of two practice trials and ten test items. The position of the odd word across trials was determined randomly and was identical for all participants.

Alliteration detection: The alliteration detection task from Gillon (2000) was used to measure the participants' ability to detect a given phoneme in word-initial position. The ability to isolate initial sounds of words is thought to be a developmental pre-cursor to phoneme segmentation skills, which are crucial for later literacy development (Lonigan et al., 1998; Major & Bernhardt, 1998; van Kleeck, Gillam & McFadden, 1998; Warrick, Rubin & Rowe-Walsh, 1993). One of the three words in each set contained the target phoneme in word-initial position. The participant was presented with a pictured character and told that the character liked words that started the same as his name (e.g., "This is my friend Hippo. Hippo starts with /h/. Hippo likes pictures that start with his sound /h/. Let's see what pictures he will like"). The investigators then presented and named three pictures, and asked the participant to select the one that began with the target phoneme. The task consisted of two practice trials and ten test items. The position of the

target word across trials was determined randomly and was identical for all participants.

Letter name knowledge: Knowledge of letter names has been shown to highly correlate with later reading skill, and to improve acquisition of phonological processing skills (Burgess & Lonigan, 1998; Webster, Plante & Couvillon, 1997). All 26 lower case letters were presented on individual cards, in four groups of six or seven. The letters were allocated to groups to provide the maximum logographic distinction. The participant was asked to select a group of letters, place them in a line along the table and then to point to each letter as it was named randomly by the investigator.

Letter-sound knowledge: Grapheme-phoneme correspondence (GPC) is a pre-requisite skill for phonological recoding, the most advanced stage of development in single word reading (Ehri, 1999). GPC knowledge is also a strong predictor of later reading success (Burgess & Lonigan, 1998; Lonigan et al., 1998; Muter, 1998; Webster et al., 1997). All 26 lower case letters were divided into four groups of six or seven letters and printed on strips of card (72 point, Arial), as described previously by Gillon (2000). Letters were divided to provide maximum phonemic distinction, so as to avoid errors due to misperception of voiced and unvoiced cognates. The strips were then inserted through slots in a cardboard face, and the child was asked to move the strip so that the face 'said' the sound (i.e. the letter visible in the mouth of the face corresponded to the phoneme the investigators produced). The investigators avoided inserting a schwa vowel after voiced phonemes and phonemes were lengthened where possible (e.g. vvv, rather than "vuh").

Initial phoneme isolation: This task was designed by Burt et al. (1999) to provide normative data on phonological processing skills in four-year old children. Participants were asked to "say just a little bit of..." twelve pictured common nouns, beginning with a range of consonants, vowels and consonant clusters. There were three training items, during which corrective feedback was provided. Responses were transcribed, one repetition was allowed and item presentation was randomised across participants, by allowing them to choose the order of picture presentation.

Phoneme blending: The phoneme blending task required the participants to identify a word, spoken by the investigator as separate phonemes (Larrivee & Catts, 1999). It was included in this assessment battery as a further measure of phonemic level skills, and the picture-pointing format ensured that speech intelligibility issues were avoided. A picture of each target word was presented on a sheet of card with two distracters. The distracter pictures were usually one word that rhymed and one that shared the same initial phoneme. All target and distracter words were CVC (consonant-vowel-consonant) structure. The participant was told: "This robot is getting old and so he speaks slower than he used to. You have to listen to what the robot says, and then point to the picture he said. He could say 'sheep', 'jeep' or 'ship'. You listen carefully and point to the picture

he says". The investigator named each picture and then presented the three phonemes of the target. There were three training items, during which corrective feedback was provided, and twelve test items.

Spelling of orthographically regular words: The participants were presented with the single letters (printed in 72 point, Arial font) that spelt the orthographically regular words spoken by the investigators, and were required to put the letters in the right order, by placing them in pockets made of coloured card. The two practice items were "mum" and "cat", followed by ten test items, using five CVC, four CVCC and one CCVCC structure.

Non-word reading: The non-word reading task required spoken responses from the participants, as such it was anticipated that it could be difficult to score, given the speech intelligibility issues frequently associated with children with Down syndrome (Evans, 1994; Iacono, 1998; Miller et al., 1999). It was included as some investigators report that speech intelligibility in children with Down syndrome improves when reading aloud (Buckley, 1985; Cossu et al., 1993; Fowler et al., 1995). This assessment was adapted from the non-word reading task used in Gillon (2000). The participant was told "these are some silly words that you have never seen before. I want you to have a go at how you think you would say these silly words". Ten orthographically regular non-words (e.g., 'vab', 'kos') written in lower case letters on individual cards, were placed face down on the table, the participants were asked to choose each card in turn and read it aloud. All responses were recorded onto an audiotape and then phonetically transcribed.

Real word reading recognition: Word recognition was assessed through a choice-of-three task developed for this study. Three primary school teachers were asked to provide a list of the basic sight words that they initially taught their class, which were then compared. Twenty of the words common to all three lists were selected as stimuli. These words were presented with two distractors (either semantic, graphic or phonologically similar) and the child was asked to indicate the word spoken by the investigator by stamping the correct word, with a Winnie the Pooh™ rubber stamp.

Procedure

Participants attended four individual assessment sessions each of approximately one-hour duration, with breaks provided as needed to maintain the child's attention and co-operation. Assessment tasks were randomly allocated into sessions so that there were four to six tasks in each session, with no more than two of the phonological awareness assessments in one session, and the two speech production assessments were in different sessions.

Results

All of the participants completed the full battery of speech, reading, hearing and phonological awareness assessments. Table 1 illustrates the variation in the participants' ages, reading level, expressive language abilities, level of speech impairment, short-term memory span and hearing level (pure-tone average).

Participant	Number of months at school	Age (months)	Burt Word Reading Test	PCC	MLU	Short Term Memory span	PTA – Best ear (dBHL)	Speech perception threshold (dBA) Kendall Toy Test
1	40	100	31	77	2.71	3	20.00	44.2
2	37	106	27	80	2.29	2	16.25	43.2
3	30	100	29	43	2.74	3	17.50	44.4
4	22	94	0	21	1.21	2	11.25	41.2
5	17	83	14	72	3.61	2	16.50	43.5
6	12	85	5	8	1.47	2	15.00	55.0
7	12	84	3	82	3.62	2	15.00	40.4
8	12	65	4	73	1.81	2	10.00	40.5
9	6	66	7	64	2.05	2	21.25	43.9
Mean	21.3	87	13.3	58.1	2.39	2.22	15.9	44.1
(SD)	(14.6)	(11.9)	(12.4)	(27.3)	(0.86)	(0.44)	(3.7)	(4.4)

Burt Word Reading Test – New Zealand Revision (Gilmore et al., 1981) = number of words read correctly

PCC = Percent of Consonants Correct

MLU = Mean Length of Utterance measured in morphemes

PTA = Pure Tone Average (The average of hearing thresholds in dBHL at 500, 1000, and 2000Hz)

Table 1. Participant performance in speech, language and reading measures.

The wide range of literacy skills within the sample was in accordance with the range in ages and time spent at school. The participants' performance in the tasks which comprised the phonological awareness battery is presented in Table 2 along with a correlation matrix (Table 3). As expected, written word recognition as measured by the Burt Word Reading Test raw scores were more highly correlated with time spent at school ($r(9) = .85, p < .01$), than with chronological age ($r(9) = .68, p < .05$). This effect was consistent across the measures of performance, reflecting the importance of when children are integrated into mainstream formal schooling. The participants varied in the age at which they had started formal reading instruction at school, thus the number of months at school is given in Table 1, alongside age in months.

As predicted, the tasks requiring a spoken response (phoneme isolation and non-word reading) were more difficult to score, due to the speech impairment of the participants. These tasks did, however, provide useful insight into the phonological awareness skills of the participants. In general, the spoken response tasks were difficult for the participants. Participants 3 and 6 achieved scores of 8% correct by producing the same phoneme in response to every pictured word.

The non-word reading score presented in Table 2 is the number of non-words the participants were able to correctly read ($x/10$). Unfortunately, most of the participants had great difficulty with this task, with only three children obtaining scores above zero. It is interesting that these three children (Participants 1, 3 & 9) also had the highest scores in the other phonological awareness activities indicating the dependence of non-word reading on the more

basic phonological awareness skills. It was thought that speech production skills, as measured by the PCC, would be related to non-word reading skills. Unfortunately, this was not the case ($r(9) = .286, p > .1$) suggesting that difficulties in the non-word reading assessment could not be explained solely by level of speech impairment.

Similar difficulty and/or poor performance was obtained with the skill of rhyme in that only one of the participants (Number 2) was able to clearly demonstrate an understanding of rhyme, although four children were able to demonstrate emergence of phoneme level awareness. As predicted, phoneme awareness skills were highly related to reading level. Significantly related to reading level were the skills of alliteration ($r(9) = .887, p < .001$), letter naming ($r(9) = .663, p < .05$), and letter sound knowledge ($r(9) = .853, p < .001$). Unfortunately, due to the small number of participants, the skills of phoneme isolation ($r(9) = .548, p > .05$), and phoneme blending ($r(9) = .573, p > .05$) while having a high correlation coefficient were not statistically related to reading level. There was no association between reading level and rhyme ($r(9) = -.002, p > .05$), most likely due to the amount of difficulty that the children had with the rhyming task.

Most participants responded to the speech perception stimuli (in the Kendall Toy Test) in the range of 40-45 dBA, reflecting the lowest level that the investigator was able to consistently present the names of the toys (40-43 dBA). Speech perception thresholds were moderately negatively correlated with speech intelligibility (as measured by PCC), $r(9) = -.63, p < .05$, indicating lower speech perception thresholds were related to higher speech intelligibility. Conversely, hearing thresholds, as measured by the pure-

Participant	Rhyme (x/3 %)	Letter- name (x/6 %)	Letter- sound (x/6 %)	Alliteration (x/3 %)	Phoneme blending (x/3 %)	Phoneme isolation (%)	Non-word reading (x/10)	Real word reading recognition (x/3 %)
1	20	100*	100*	100*	83*	63*	6*	100*
2	70*	100*	92*	66*	41	0	0	100*
3	50	100*	100*	83*	75*	8	2*	85*
4	40	38*	24	25	25	0	0	55
5	30	100*	92*	66*	92*	58*	0	90*
6	40	100*	56*	25	50	8*	0	55
7	40	52*	4	33	50	0	0	45
8	50	92*	84*	41	66	0	0	70*
9	60	100*	83*	41	33	25*	1*	65
Mean	44.4	86.2	63.1	53.3	57.3	18%	0.78	73.8
(SD)	(15.1)	(25.3)	(35.3)	(26.7)	(23.0)	(25.4)	(0.19)	(20.6)

* = Score significantly above chance levels (Maclean et al., 1987).

Table 2. Participants' percent correct in the phonological awareness tasks.

	Age (mths)	Time at school (mths)	Rhyme	Alliteration	Letter-name	Letter-sound	Phoneme isolation	Phoneme blending	Real-word reading	Non-word reading	BURT	PCC	STM	Kendall Toy Test	PTA
Age (mths)	1.00														
Time at school (mths)	.90***	1.00													
Rhyme	-.09	-.12	1.00												
Alliteration	.52	.75**	-.23	1.00											
Letter-name	-.03	.22	.15	.55	1.00										
Letter-sound	.11	.42	.12	.74	.90***	1.00									
Phoneme isolation	.05	.23	-.64*	.62*	.43	.50	1.00								
Phoneme blending	.10	.28	-.56	.70*	.50	.56	.66*	1.00							
Real-word reading	.49	.74**	-.00	.89***	.66*	.85***	.55	.57	1.00						
Non-word reading	.25	.51	-.55	.63*	.24	.34	.69*	.35	.45	1.00					
BURT	.68*	.84**	-.01	.94***	.58	.72*	.42	.52	.88***	.51	1.00				
PCC	-.09	.12	.08	.45	.15	.26	.30	.34	.44	.29	.33	1.00			
STM	.50	.65*	-.35	.81**	.31	.48	.39	.53	.51	.63*	.76**	.05	1.00		
Kendall Toy Test	.08	.01	-.11	-.12	.45	.12	.07	.02	-.08	.01	.03	-.64*	.03	1.00	
PTA best ear	.48	.42	.28	.52	.41	.52	.11	.41	.64*	-.29	.61*	.18	.22	-.05	1.00
MLU	.12	.07	-.29	.46	.06	.07	.44	.61*	.27	.12	.32	.65*	.22	-.31	.42

* = $p < .05$ ** = $p < .01$ *** = $p < .001$ **Table 3. Pearson's correlation matrix of the results across the tests.**

tone audiogram were not related to speech intelligibility ($r(9) = .178$, $p > .05$). Thus indicating that perception of speech, rather than hearing level are more sensitive predictors of speech intelligibility.

Short-term memory (STM) assessment revealed minimal differences between the participants. The scores of 2-3 items is considerably less than typically developing children of the same age or reading level (Chi, 1977; Laws, Buckley, MacDonald, Broadley & Bird, 1995). Correlation analysis was performed with the STM data to determine if there was

any relationship between STM and reading or phonological awareness skills. STM was significantly correlated with alliteration detection ($r(9) = .81$, $p < .01$); BURT reading level ($r(9) = .76$, $p < .02$); and the number of whole non-words correctly read ($r(9) = .634$, $p < .05$). This suggests that greater STM capabilities are associated with increased levels of processing of phonological information, and may be a link between phonological awareness and general cognitive skills. Due to the reduced variability of scores on the STM task this result should be regarded with caution.

Discussion

This study provides an insight into the phonological awareness skills of young children with Down syndrome and the relationship to reading achievement, speech-language abilities, and level of hearing impairment. At the outset, it is important to note that reading was assessed solely at the text decoding level. Reading comprehension, the ability to extract meaning from the written form, was outside the scope of this investigation. The participants who achieved the highest scores in phoneme awareness measures also achieved higher scores in the measures of literacy, supporting the hypothesis that there would be a link between phoneme level awareness and text decoding skills in children with Down syndrome.

While the better readers were able to display phonemic level awareness, and in some cases strong grapheme-phoneme connections, only one participant scored significantly above chance level for rhyme detection, as the task format restricted variance of scores. There are questions to be addressed concerning the nature of the rhyming task used in the phonological awareness battery, and its suitability for this population. In typically developing children, the ability to recognise rhyme emerges between three and four years of age, with most children scoring at ceiling levels in tests of rhyme once they start school (Bryant, MacLean, Bradley & Crossland, 1990; Lonigan et al., 1998; Warrick et al., 1993). The result that only one child had developed rhyme was surprising, as three participants had well developed phoneme level awareness (as evidenced by achievement in the alliteration detection, phoneme isolation, and phoneme blending tasks), which is a developmentally higher level of phonological awareness than rhyme.

There are three likely explanations for this result. First, the rhyme task may have been too difficult for the participants. The odd-one-out format required the participants to listen to three words spoken by the investigator, identify the two that formed a rhyming pair and then cross out the picture that was not a part of the pair. This sequence may have placed too high a cognitive load for the participants. Second, phoneme level awareness skills were assessed with using different tasks, enabling grouping of the phoneme level data, and overcoming format-specific effects. Third, rhyme skills may not relate to literacy acquisition for children with Down syndrome. Performance in the rhyme detection task was not significantly correlated with any other phonological awareness or literacy measure, unlike the phoneme level awareness measures which were significantly correlated with each other, and with the number of words read correctly on the Burt Word Reading Test.

Given that recoding written words involves the use of grapheme-phoneme connections and phoneme level awareness, it is possible that the participants who were more advanced in reading ability had developed phoneme level awareness through the process of learning to read. Typically developing children demonstrate bi-directional influence between phonological awareness and literacy development (Burgess & Lonigan, 1998; Wagner et al.,

1997). They approach literacy instruction with skills in rhyme and phonemic level awareness that aid them in grasping the alphabetic principle, and continue to develop with exposure to literacy instruction and success (Share & Stanovich, 1995). Given that none of the participants in this study demonstrated rhyme awareness, it is possible that they began literacy instruction with phonological awareness deficits, thus reducing the reciprocal relationship between phonological awareness and literacy to a uni-directional influence from reading to *phoneme* awareness, without growth in rhyme skills. The finding that phoneme awareness skills were significantly correlated with reading level suggests that phoneme awareness is a likely by-product of learning to decode text in children with Down syndrome, whereas rhyme is not. This is consistent with the work of Fowler et al. (1995), who also revealed a strong association between phoneme awareness and literacy acquisition, in young adults with Down syndrome, and is in conflict with the findings of Kay-Raining Bird et al. (2000), who observed growth in rhyme production skills with increasing chronological age, and reading level.

Short-term memory was impaired in all the participants, compared to typically developing children of the same reading level (Laws et al., 1995), and correlated with both reading level and alliteration detection scores. Fowler, et al. (1995) found short-term memory to be highly correlated with reading level, and concluded that a minimum digit span of four was necessary for achieving success in phonological recoding of words. The results of this study appear to support that claim: the two participants who were able to read at least two non-words, were also the only participants to achieve short-term memory span of three. Kay-Raining Bird et al. (2000) found that when phoneme segmentation scores were partialled out, the correlation between short-term memory and non-word decoding remained high and significant. This result is consistent with the recommendation that intervention efforts should avoid focusing directly on improving short-term memory (Lahey, 1988).

Despite the high incidence of abnormal tympanogram results and the presence of a mild hearing impairment in 55% of the participants, hearing thresholds did not correlate with any of the phonological awareness measures. Speech perception test results correlated moderately with degree of speech impairment, but no relation was found between speech perception and pure-tone thresholds. Hearing level does not appear to influence phonological awareness or literacy acquisition for the participants in this study. The participants' history of hearing loss (i.e. frequent and extent of middle ear pathology) was not accounted for in these analyses, and may contribute to literacy development. Furthermore, the participants presented with only mildly increased pure-tone thresholds, there may be a stronger connection between hearing acuity and phonological awareness in children with Down syndrome with more severe hearing deficits (Marcell, 1995; Pueschel & Sustrova, 1996) or children not under a programme of active audiological and otological management.

Limitations of the investigation

The current study investigated reading level at the text decoding level only, reading comprehension was not evaluated. Although phonological recoding is necessary for fluent reading, it is not sufficient (Kamhi & Catts, 1999; Tunmer & Chapman, 1998). The current results outline a subset of skills involved in the reading process for children with Down syndrome. Proficient readers add lexical, morpho-syntactic and semantic knowledge to phonological awareness skills (Ehri, 1992). The number of participants (N=9) limits the generalisation of the findings to other children with Down syndrome; however, the heterogeneity of the participants' reading and phonological awareness abilities provides a range of profiles and may balance this limitation. Of additional concern is that with a total number of nine participants, the power of the statistical analysis may be compromised. The importance of the results lies in differences in success of the children on the different measures of phonological awareness as well as in interpreting broad relationships between skills.

The use of a control group matched for reading level would have allowed for comparison of phonological awareness skills in relation to literacy level, especially as the phonological awareness assessment tasks were non-standardised (Troia, 1999). There are questions about the suitability of the rhyme assessment, it is unclear whether scores in this task reflected rhyme abilities, or were confounded by the odd-one-out format. The high chance levels in some of the phonological awareness assessments also reduced the statistical power of the analyses.

Evaluation of the assessment procedures

Given the methodological limitations inherent in some of the previous studies of phonological awareness in children with Down syndrome (Cossu et al., 1993; Evans, 1994), this investigation aimed to develop measures of phonological awareness that were suitable for demonstrating emergence of skill, and were motivating for the participants. In general, the use of pictures in the assessments and incorporating them into game-like formats helped maintain motivation and attention in the participants. The use of pictures also reduced the impact of auditory short-term memory deficits on performance.

In addition to difficulties associated with the rhyme detection assessment, other tasks also presented difficulties in the analysis, due to the chance levels inherent in the design. By providing the participant with a limited choice of pictures or letters to respond with, as was the case for alliteration detection, phoneme blending, letter-name and letter-sound, spelling and real word reading recognition, there was a chance that the participants could accurately guess the correct response. This left a very narrow window for variance among scores significantly above chance and highlights the difficulties associated with assessing phonological awareness in children with Down syndrome. It is recommended that future studies of phonological awareness skills with children with Down syndrome use more

than one assessment of rhyme detection and also include a measure of rhyme production, as was used by Kay-Raining Bird et al. (2000).

The use of standardised tests of reading ability with children with Down syndrome can be problematic, because of floor effects (Fowler et al., 1995) and poor motivation. There was, however, a highly significant positive correlation between number of words read correctly on the Burt Word Reading Test and scores on the choice-of-three real word reading recognition test developed by the investigator. The choice-of-three task was generally met with enthusiasm by the participants, probably because of the Winnie the Pooh™ stamp, and higher number of early sight words in the stimuli.

Directions for future research

Future research should focus on the effects of alternative task formats in allowing children with Down syndrome to best demonstrate their phonological awareness knowledge, and seek to overcome the limitations of the odd-one-out rhyme task. Investigation is required into the development of phonological awareness skills in children with Down syndrome, to determine the level of phonological awareness they bring to the task of learning to read, and the influence of rhyme and phoneme awareness in the process of literacy acquisition.

The findings indicate that children with Down syndrome have phonological awareness deficits, future investigations should seek to replicate these findings, as there appears to be inconsistencies between this study and other published literature as to the nature of this deficit (Kay-Raining Bird et al., 2000). In defining the phonological awareness skills of children with Down syndrome, future studies should employ more than one measure of each phonological awareness construct, seeking to avoid high chance levels and task effects.

Acknowledgments

The authors would like to thank the nine children and families for participation in the research project. In addition the Down Syndrome Association of New Zealand (Canterbury branch) and the Champion Centre assisted in the investigation. The authors would like to thank the comments of Dr Rhea Paul, Dr Gail Gillon and the two anonymous reviewers of this paper for providing the constructive and supportive feedback required for an improved paper. This research project was partially supported by an Oticon Foundation in New Zealand research grant.

Correspondence

Mark C. Flynn • Oticon A/S, Strandvejen 58, DK-2900 Hellerup, Denmark • E-mail: mcf@oticon.dk

References

- Bennetts, L.K. & Flynn, M.C. (2002). Improving the classroom listening skills of children with Down syndrome by using soundfield FM. *Down Syndrome Research and Practice*, 8, 19-24.
- Bower, A. & Hayes, A. (1994). Short term memory deficits and Down syndrome: A comparative study. *Down Syndrome Research and Practice*, 2, 47-50.
- Broadley, I. & MacDonald, J. (1993). Teaching short term memory skills to children with Down syndrome. *Down Syndrome Research and Practice*, 1, 56-62.
- Bryant, P.E., MacLean, M., Bradley, L.L. & Crossland, J. (1990). Rhyme and alliteration, phoneme detection, and learning to read. *Developmental Psychology*, 26(3), 429-438.
- Buckley, S. (1985). Teaching parents to teach reading to teach language: A project with Down's syndrome children and their families. In K. Topping & S. Wolfendale (Eds.), *Parental involvement in children's reading*. London: Croom Helm.
- Buckley, S., Bird, G. & Byrne, A. (1996). The practical and theoretical significance of teaching literacy skills to children with Down's syndrome. In J. A. Rondal, J. Perera, L. Nadel & A. Comblain (Eds.), *Down's syndrome. Psychological, psychobiological and socio-biological perspectives* (pp. 119-128). London: Whurr.
- Burgess, S.R. & Lonigan, C.J. (1998). Bidirectional relations of phonemic sensitivity and pre-reading abilities: Evidence from a preschool sample. *Journal of Experimental Child Psychology*, 70, 117-141.
- Burt, L., Holm, A. & Dodd, B. (1999). Phonological awareness of 4-year-old British children: An assessment and development data. *International Journal of Language and Communication Disorders*, 34, 311-335.
- Byrne, A., Buckley, S., MacDonald, J. & Bird, G. (1995). Investigating the literacy, language and memory skills of children with Down syndrome. *Down Syndrome Research and Practice*, 3, 53-58.
- Chapman, R.S., Seung, H.K., Schwartz, S.E. & Kay-Raining Bird, E. (1998). Language skills of children and adolescents with Down syndrome: II. Production deficits. *Journal of Speech, Language, and Hearing Research*, 41, 861-873.
- Chi, M. (1977). Age differences in memory span. *Journal of Experimental Child Psychology*, 23, 226 - 281.
- Cossu, G., Rossini, F. & Marshall, J.C. (1993). When reading is acquired but phonological awareness is not: A study of literacy in children with Down syndrome. *Cognition*, 46, 129-138.
- Cupples, L. & Iacono, T. (2000). Phonological awareness and oral reading skill in children with Down syndrome. *Journal of Speech, Language and Hearing Research*, 43, 595-608.
- Dale, D.M.C. (1962). *Applied audiology for children*. Illinois: Thomas.
- Davies, B. (1985). Hearing problems. In D. Lane & B. Stratford (Eds.), *Current approaches to Down's syndrome* (pp. 85-102). London: Holt, Rinehart & Wilson.
- Ehri, L.C. (1992). Reconceptualizing the role of sight word reading and its relationship to recoding. In P. Gough, L. Ehri & R. Treiman (Eds.), *Reading acquisition* (pp. 107-143). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Ehri, L.C. (1999). Word reading by sight and by analogy in beginning readers. In C. Hulme & R.M. Joshi (Eds.), *Reading and spelling: Development and disorders* (pp. 87-111). Mahwah, NJ: Lawrence Erlbaum Associates Inc.
- Evans, R. (1994). Phonological awareness in children with Down syndrome. *Down Syndrome Research and Practice*, 2, 102-105.
- Fletcher, H. & Buckley, S. (2002). Phonological awareness in children with Down syndrome. *Down Syndrome Research and Practice*, 8, 11-18.
- Fowler, A.E., Doherty, B.J. & Boynton, L. (1995). The basis of reading skill in young adults with Down syndrome. In L. Nadel & D. Rosenthal (Eds.), *Down syndrome: Living and learning in the community* (pp. 182-196). New York: Wiley-Liss.
- Gillon, G.T. (2000). The efficacy of phonological awareness intervention for children with spoken language impairment. *Language, Speech, and Hearing Services in Schools*, 31, 126-141.
- Gilmore, A., Croft, C. & Reid, N. (1981). *Burt Word Reading Test New Zealand Revision*. Wellington, New Zealand: NZCER.
- Hodson, B.W. (1986). *The Assessment of Phonological Processes - Revised*. Danville, Illinois: The Interstate Printers & Publishers.
- Iacono, T.A. (1998). Analysis of the phonological skills of children with Down syndrome from single word and connected speech samples. *International Journal of Disability, Development and Education*, 45, 57-73.
- Iino, Y., Imamura, Y., Harigai, S. & Tanaka, Y. (1999). Efficacy of tympanostomy tube insertion for otitis media with effusion in children with Down syndrome. *International Journal of Pediatric Otorhinolaryngology*, 49, 143-149.
- Kamhi, A. G. & Catts, H. W. (1999). Reading development. In H.W. Catts & A.G. Kamhi (Eds.), *Language and reading disabilities* (pp. 25-49). Needham Heights, MA: Allyn & Bacon.
- Kay-Raining Bird, E., Cleave, P.L. & McConnell, L. (2000). Reading and phonological awareness in children with Down syndrome: A longitudinal study. *American Journal of Speech-Language Pathology*, 9, 319-330.
- Lahey, M. (1988). *Language disorders and language development*. New York, NY: MacMillan Publishing.
- Larrivee, L.S. & Catts, H.W. (1999). Early reading achievement in children with phonological disorders. *American Journal of Speech-Language Pathology*, 8, 118-128.
- Laws, G., Buckley, S., MacDonald, J., Broadley, I. & Bird, G. (1995). The influence of reading instruction on language and memory development in children with Down syndrome. *Down Syndrome Research and Practice*, 3, 59-64.
- Long, S.H. & Schroeder, C. (1999). *PROPHet (Version 1.0)*. Cleveland, OH: Case Western Reserve University.
- Lonigan, C.J., Burgess, S.R., Anthony, J.L. & Barker, T.A. (1998). Development of phonological sensitivity in two- to five-year old children. *Journal of Educational Psychology*, 90, 294-311.

- Maclean, M., Bryant, P. & Bradley, L. (1987). Rhymes, nursery rhymes and reading in early childhood. *Merrill-Palmer Quarterly*, 33, 255-281.
- Major, E.M. & Bernhardt, B. (1998). Metaphonological skills of children with phonological disorders before and after phonological and metaphonological intervention. *International Journal of Language and Communication Disorders*, 33, 413-444.
- Marcell, M.M. (1995). Relationships between hearing and auditory cognition in Down syndrome youth. *Down Syndrome Research and Practice*, 3, 75-91.
- Marcell, M.M. & Cohen, S. (1992). Hearing abilities of Down syndrome and other mentally handicapped adolescents. *Research in Developmental Disabilities*, 13, 533-551.
- Marcell, M.M. & Weeks, S.L. (1988). Short-term memory difficulties and Down's syndrome. *Journal of Mental Deficiency Research*, 32, 153-162.
- Miller, J.F. (1981). *Assessing language production in children: Experimental procedures*. Austin, TX: Pro-Ed.
- Miller, J.F. (1987). Language and communication characteristics of children with Down syndrome. In S.M. Pueschel (Ed.), *New perspectives on Down syndrome* (pp. 233-268). Boston, MA: Paul H. Brookes Publishing Co.
- Miller, J.F., Leddy, M. & Leavitt, L.A. (1999). *Improving the communication of people with Down syndrome*. Baltimore: Brookes Publishing Co.
- Muter, V. (1998). Phonological awareness: Its nature and its influence over early literacy development. In C. Hulme & R.M. Joshi (Eds.), *Reading and spelling: Development and disorders*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Palmer, C.V. (1997). Hearing and listening in a typical classroom. *Language, Speech, and Hearing Services in Schools*, 28, 213 - 218.
- Pueschel, S.M. & Sustrova, M. (1996). Visual and auditory perception in children with Down's syndrome. In J.A. Rondal, J. Perera, L. Nadel & A. Comblain (Eds.), *Down's syndrome. Psychological, psychobiological and sociobiological perspectives* (pp. 53-63). London: Whurr.
- Share, D. & Stanovich, K. (1995). Cognitive processes in early reading development: Accommodating individual differences into a model of acquisition. *Issues in Education*, 1, 1-57.
- Troia, G. A. (1999). Phonological awareness intervention research: A critical review of the experimental methodology. *Reading Research Quarterly*, 34, 28-52.
- Tunmer, W.E. & Chapman, J.W. (1998). Language prediction, phonological recoding ability, and beginning reading. In C. Hulme & R.M. Joshi (Eds.), *Reading and spelling: Development and disorders*. Mahwah, NJ: Lawrence Erlbaum Associates.
- van Kleek, A., Gillam, R.B., & McFadden, T.U. (1998). A study of classroom based phonological awareness training for preschoolers with speech and/or language disorders. *American Journal of Speech-Language Pathology*, 7(3), 65-76.
- Varnhagen, C.K., Das, J.P. & Varnhagen, S. (1987). Auditory and visual memory span: Cognitive processing by TMR individuals with Down syndrome or other etiologies. *American Journal of Mental Deficiency*, 4, 398 - 405.
- Wagner, R.K., Torgesen, J.K. & Rashotte, C.A. (1994). Development of reading related phonological processing abilities: New evidence of bi-directional causality from a latent variable longitudinal study. *Developmental Psychology*, 30, 73-87.
- Warrick, N., Rubin, H. & Rowe-Walsh, S. (1993). Phoneme awareness in language delayed children: Comparative studies and intervention. *Annals of Dyslexia*, 43, 153-173.
- Webster, P.E., Plante, A.S. & Couvillion, L.M. (1997). Phonologic impairment and pre-reading: Update on a longitudinal study. *Journal of Learning Disabilities*, 30(4), 365-375.
- Wood, C. & Terrell, C. (1998). Pre-school phonological awareness and subsequent literacy development. *Educational Psychology*, 18, 253-274.