Intensive speech and language therapy for older children with cerebral palsy: a systems approach

LINDSAY PENNINGTON | NICK MILLER | SHEILA ROBSON | NICK STEEN

Institute of Health and Society, Royal Victoria Infirmary, Newcastle upon Tyne, UK.

Correspondence to Dr Lindsay Pennington, Institute of Health and Society, University of Newcastle, Sir James Spence Institute, Royal Victoria Infirmary, Newcastle upon Tyne NE1 4LP, UK. E-mail: lindsay.pennington@ncl.ac.uk

PUBLICATION DATA
Accepted for publication 2nd April 2009.
Published online 16th September 2009.

AIM To investigate whether speech therapy using a speech systems approach to controlling breath support, phonation, and speech rate can increase the speech intelligibility of children with dysarthria and cerebral palsy (CP).

METHOD Sixteen children with dysarthria and CP participated in a modified time series design. Group characteristics were as follows: seven males, nine females; age range 12 to 18 years (mean 14y, SD 2); CP type: nine spastic, two dyskinetic, four mixed, one Worster–Drought; Gross Motor Function Classification System levels range I to V (median IV). Children received three 30- to 45-minute sessions of individual therapy per week for 6 weeks. Intelligibility in single words and connected speech was compared across four points: 1 week and 6 weeks before therapy, and 1 week and 6 weeks after its completion. Three familiar listeners and three unfamiliar listeners scored each recording. Mean percentage intelligibility was compared using general linear modelling techniques.

RESULTS After treatment, familiar listeners understood 14.7% more single words and 12.1% more words in connected speech. Unfamiliar listeners understood 15% more single words and 15.9% more words in connected speech after therapy.

INTERPRETATION Therapy was associated with increases in speech intelligibility. Effects of the therapy should be investigated further, in an exploratory trial with younger children and in a randomized controlled trial.

About 50% of children with cerebral palsy (CP) have communication disorders,[1,2] the most common cause of which is dysarthria. Dysarthria can be associated with any type of CP and can arise from any part of the vocal tract. Children with dysarthria associated with CP often have shallow, irregular breathing for speech (for instance speaking on small pockets of residual air; trying to produce a whole utterance rapidly on one short breath) and this may affect the rate at which they attempt to speak.[3–6] They may also have what is perceived as a low-pitched, harsh-sounding voice, with little pitch variation. Hyper-nasal speech with audible escape of air through the nose and poor articulation may further reduce intelligibility.[3,4,7] Disorders are more severe for children with dyskinetic CP than for those with spastic forms,[4,7] but most of the perceptual characteristics (e.g. low pitch, poor breath control and imprecise articulation) are observed in children across the different types of CP.

Therapy to reduce motor speech impairments and the intelligibility limitations they impose has been described.[4–6,8] A systems approach that targets the components of the vocal tract controlling breathing, phonation, nasal resonance, articulation and intonation is commonly advocated, and is similar to intervention for adults with acquired dysarthria.[6] For example, treatment may focus on regulating breathing to support speech across short phrases. Intervention also involves slowing children's speech rate, to allow more precise movement of muscles in the oral tract.[5] Yorkston et al. also advocate increasing respiratory effort and focusing on maximizing jaw movements in speech to increase oral cavity volume and, thereby, increase loudness and decrease excess nasality. The use of speech and nonspeech exercises to facilitate velopharyngeal closure and decrease nasality has also been described.[6] Articulation treatment is only advised when other aspects of speech production have been or are being addressed, because imprecise speech sounds are usually due to problems in controlling respiration, phonation, and the velopharynx, rather than solely the lips and tongue.[5] Thus, more precise articulation and improved intelligibility are achieved through developing control of breathing for speech, increasing respiratory effort, and slowing speech rate.[4–6] Treatment for overall speech naturalness (prosody) comprises exercises aimed at controlling speaking rate, appropriateness of pauses used between words, loudness and, where necessary, pitch variation.[5,6]

DOI: 10.1111/j.1469-8749.2009.03366.x

Although approaches to dysarthria treatment for children with CP have been well documented, a systematic review[9] has shown a dearth of evidence for their effectiveness. We undertook an exploratory study to test the potential effects of treatment, focusing on controlling breath support, phonation, and rate with older children who have dysarthria arising from CP, and to test the feasibility of conducting a rigorous pragmatic trial. We used a group interrupted time-series study design, in which children acted as their own controls, using as a main outcome measure the intelligibility of children's speech in single words and connected speech to familiar and unfamiliar listeners at two points before and two points after intervention.

METHOD

Participants

Children receiving therapy

Sixteen children with CP and dysarthria (nine females, seven males, age range 12–18y; mean 14y, SD 2) were recruited in the north of England by means of local speech and language therapists. The sample size of the study was determined by feasibility, given the number of children who could be treated during a term at one school, with restrictions imposed by the length of the school day, school timetables, and holidays. Children were eligible for the study if they had a diagnosis of CP, were aged 11 to 19 years, and had dysarthria classed as moderate to severe by local therapists. Sex was not an issue for recruitment because there is no evidence that changes in voice production during puberty affect the speech production of adolescents with dysarthria any differently from that of adolescents without CP, or that sex influences response to dysarthria treatment. Children were excluded from the study if they had one or more of the following: bilateral hearing impairments greater than 50dB hearing loss, which would affect their ability to hear differences in speech production; severe visual impairments not correctable with spectacles, which would prevent the interpretation of cartoon drawings in the connected speech stimuli; or profound cognitive impairments or difficulties in following simple instructions, which would reduce children's ability to understand and comply with therapy tasks. Nine children had spastic CP, two had dyskinetic, four had mixed (spastic and dyskinetic) and one child had Worster–Drought syndrome.[10] The motor disorders of all children except the child with Worster–Drought syndrome were bilateral. Gross Motor Function Classification System[11] levels ranged from I to V (median IV). See Table I for children's characteristics.

Table I: Participants' characteristics

Characteristic	Value
Sex, males/females *n*	7/9
Age (y), mean (SD)	14 (2)
Type of cerebral palsy, *n*	
Spastic	9
Dyskinetic	2
Mixed	4
Worster–Drought syndrome	1
GMFCS level, *n*	
I	1
II	4
III	2
IV	5
V	4
Dysarthria severity, *n*	
Moderate	6
Severe	10
Number of sessions completed, mean (SD)	15.5 (1.9)

Listeners

To calculate children's speech intelligibility, adults listened to recordings of children's speech. Three members of school staff who worked with each child were recruited as familiar listeners for the study. One hundred and twenty adults with no experience of people with CP or disordered speech acted as unfamiliar listeners.

Measures

Single word intelligibility was measured with the Children's Speech Intelligibility Measure.[12] This assessment comprises 200 lists of 50 single words, which the child repeats. Words are balanced in length and articulatory complexity. Listeners select the word they think they have heard from a list of 10 phonetically similar words. Different lists were allocated to each of the children at each data collection point.

Intelligibility of connected speech was measured from children describing sequences of three pictures. Four sets of picture sequences were used. To reduce variability, we set an upper limit of 60 seconds of connected speech for use in the intelligibility calculation. If recordings lasted more than 60 seconds, the first 60 seconds were selected.

The acceptability of the intervention was evaluated with a questionnaire developed for Child Mental Health Service evaluation[13] (in which children rated the acceptability of treatment using a three-point Likert scale).

Procedure

Sunderland local research ethics committee approved the study. Children's guardians provided written consent to participate in the study. Children also gave written or verbal assent. Children's measures for single word and connected speech were recorded with an EDIROL R1 digital recorder (Roland, Japan) and a head-mounted microphone. Two recordings were made at four different time points: 6 weeks before therapy (time 1), 1 week before therapy (time 2), 1 week after therapy completion (time 3), and 6 weeks after therapy completion (time 4). In the 6 weeks before the experimental treatment, children continued to receive their regular speech and language therapy. The four data collection points allowed us to gauge the change in intelligibility arising from maturation or usual therapy and the immediate and medium-term effects of the therapy.

Children received three individual sessions of therapy per week at school for 6 weeks with a research speech and language therapist (SR). Sessions lasted for 35 to 40 minutes and took place on different days. This duration and intensity of treatment was selected for three reasons: it allowed frequent practise of new motor behaviours,[14] it is similar to that found to be effective with adults,[15] and it was acceptable to children.[16] The intervention protocol was developed from previous research[3,5,6] and focused on stabilizing the students' respiratory and phonatory effort and control, speech rate and phrase length, or syllables per breath. Children first practised coordinating the onset of phonation with the beginning of exhalation in sustained vowels. They then moved on to coordinating exhalation and phonation for the production of spoken language. In the spoken language tasks, children also practised speaking slowly and maintaining breath supply across a phrase, taking a new breath at syntactically appropriate places. Four hierarchical exercises were used in the spoken language tasks. The exercises involved children (1) producing a set of 10 frequently used phrases (e.g., 'Hi mum, I'm home') and moving on to novel phrases consisting of (2) single words, (3) sentences, and (4) conversational speech. The criterion for advancement to the next exercise was set at 90%, in which children maintained controlled respiration/phonation over the entire segment of speech (e.g., a single word in exercise 2, a conversational turn in exercise 4). Therapy followed motor learning principles, incorporating high-intensity practice, random practice of target behaviours within each exercise and then between exercises once the criterion was reached, frequent feedback initially to aid skill acquisition, and then fading feedback to promote skill retention, knowledge of results and knowledge of performance.[17–20] Children were also given a stimulus or cue phrase that others could use to prompt children to use their new speech skills. While receiving this therapy and for 6 weeks after its completion, children did not receive any other speech and language therapy. Six weeks after therapy completion, children's views of the treatment were elicited by using measure 3.

Speech recordings were transferred to computer files with Creative Wave software (version 6.20.13; Creative Technology Ltd, Singapore). Only one child (C15, time 4) spoke for more than 1 minute in the connected speech task. The first 60 seconds of speech spoken was selected for analysis, comprising 27 words. Recordings were played to listeners in standard conditions, with speech played at the volume at which it was originally produced (i.e. not amplified or reduced in volume).

For familiar listeners, one of the two recordings from each of the four time points from each child was selected at random. For each familiar listener the order in which the four recordings were heard was randomized. Unfamiliar listeners were randomly allocated three recordings, with the constraint that listeners heard the same child only once. Therefore, each recording was heard by three unfamiliar listeners. The single-word condition followed the instructions of the Children's Speech Intelligibility Measures: listeners heard a word and selected from a choice of 10 phonetically similar words, presented in a vertical written list, the word that they believed they had heard. In the connected-speech condition, listeners heard a phrase and wrote down the words they had heard. The number of words heard correctly was calculated, giving the percentage intelligibility. We thus examined intelligibility rather than the ability to convey meaning (e.g. listeners reporting that a child was talking about a particular subject or giving a précis of the child's speech). The recordings were played only once. The volume of the recordings was the same for each listener. Listeners were instructed to record the words they had heard or thought they had heard. All listeners were blind to the time points of the speech they were rating.

Statistical analysis

For both single-word intelligibility and connected-speech intelligibility scores took the form of the percentage of words understood by the listener. Generalizability theory[21] was used to derive appropriate interrater reliability coefficients. Analysis of variance (ANOVA) models appropriate to the structure of the data were fitted with different models being used for familiar and unfamiliar listeners.

Familiar listeners

For each child, four recordings were each rated by three familiar listeners. Agreement between raters was assessed for each child by calculating the intraclass correlation coefficient based on a two-way ANOVA model with recordings and raters fitted as random effects. The mean of these coefficients was used to assess the interrater agreement across all children. To investigate change over time, the mean rating for each child was determined at each of the four time points. These means were then analysed with repeated-measures ANOVAs.

Unfamiliar listeners

For each child, eight recordings were rated by up to three unfamiliar listeners. Agreement between raters was assessed by using the intraclass correlation coefficient based on a two-way ANOVA with recorded samples and listeners fitted as random effects. Change over time was investigated by using a three-level multilevel model with ratings nested within recordings nested within children. Differences between occasions and differences between listeners were included as fixed effects.

Agreement between familiar and unfamiliar listeners was assessed by calculating the mean intelligibility score for each recorded sample for each type of rater. Then the intraclass correlation coefficient was calculated based on a two-way ANOVA mode recording by rater type. Mean intelligibility scores were then calculated for each child. Ratings from familiar and unfamiliar listeners were compared using a paired t-test. Similarly, using the mean scores for each child, single speech scores were compared with connected speech scores using a paired t-test.

Analysis was undertaken with SPSS for Windows (version 15 (SPSS Inc., Chicago, IL, USA) and MLwiN (version 2.02 Centre for Mulitilevel Modelling, University of Bristol, UK).

RESULTS

Intelligibility scores for individuals are shown in Table II. Mean single and connected speech scores by time by occasion are given for both familiar and unfamiliar listeners in Table III.

Table II: Intelligibility to familiar and unfamiliar listeners at each time point

	Familiar listeners[a]								Unfamiliar listeners[b]							
	Single-word percentage intelligibility				Connected-speech percentage intelligibility (n)[c]				Single-word percentage intelligibility				Connected-speech percentage intelligibility (n)[c]			
Child	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
A	30.67	26.00	44.00	55.33	24.13 (28)	34.62 (21)	25.50 (27)	39.77 (36)	18.67	13.33	22.00	40.00	7.10 (28)	7.90 (21)	8.63 (27)	20.33 (36)
B	60.00	68.00	71.00	65.33	87.37 (37)	86.97 (41)	93.93 (66)	89.83 (27)	48.00	40.67	56.67	51.33	37.80 (41)	43.77 (41)	85.83 (66)	74.13 (27)
C	60.67	56.67	79.33	74.67	65.47 (29)	77.70 (46)	77.43 (37)	74.27 (35)	50.67	43.33	66.67	68.00	17.20 (29)	54.83 (46)	46.80 (37)	57.10 (35)
D	73.33	86.67	88.00	86.67	73.10 (31)	72.53 (34)	94.60 (37)	98.13 (54)	62.00	84.00	85.00	83.00	55.90 (31)	67.57 (34)	81.03 (37)	98.00 (54)
E	48.67	26.00	57.33	55.33	5.00 (20)	47.30 (19)	49.97 (30)	78.77 (33)	56.67	62.00	50.00	90.67	61.03 (20)	70.47 (19)	34.40 (30)	98.73 (33)
F	20.00	16.00	32.00	31.33	3.47 (19)	11.10 (54)	19.63 (44)	13.30 (30)	24.00	12.00	22.67	31.33	5.25 (19)	10.47 (54)	4.50 (44)	10.00 (30)
G	52.00	59.33	79.67	60.67	79.77 (33)	28.33 (20)	77.27 (22)	71.40 (21)	48.67	39.33	66.00	50.67	58.33 (33)	11.67 (20)	63.53 (22)	26.23 (21)
H	51.33	46.67	48.67	56.00	22.53 (31)	29.77 (19)	19.40 (36)	36.80 (38)	42.67	32.00	34.00	50.67	6.40 (32)	2.60 (19)	15.25 (36)	20.93 (38)
I	47.33	51.33	65.33	61.33	62.77 (43)	78.27 (43)	48.77 (28)	82.33 (34)	43.33	48.00	64.00	52.67	29.13 (43)	12.50 (43)	57.10 (28)	35.25 (34)
J	–	44.67	54.67	38.67	–	56.47 (23)	74.07 (27)	41.60 (32)	–	36.67	43.33	32.67	–	18.77 (23)	23.43 (27)	42.63 (32)
K	55.33	61.33	72.67	57.33	67.27 (51)	57.67 (57)	39.53 (48)	52.77 (16)	47.33	45.33	56.00	52.67	15.07 (51)	16.60 (57)	9.95 (48)	10.43 (16)
L	14.00	8.67	16.67	22.67	0.00 (11)	2.47 (14)	7.33 (8)	8.30 (12)	21.33	11.33	11.33	11.33	3.00 (11)	0.00 (14)	0.00 (8)	2.77 (12)
M	36.67	27.33	25.33	32.67	20.00 (10)	25.80 (8)	24.93 (10)	39.87 (15)	40.00	16.00	13.33	32.00	10.00 (10)	12.33 (8)	20.00 (10)	17.77 (15)
N	69.33	20.67	74.67	78.67	38.30 (18)	3.67 (23)	82.43 (19)	73.53 (19)	50.00	22.67	69.00	77.33	35.17 (18)	1.43 (23)	80.00 (19)	54.33 (19)
O	50.00	51.00	90.00	90.00	68.15 (22)	86.90 (26)	76.00 (25)	88.85 (27)	36.67	18.00	69.33	90.00	40.57 (22)	33.30 (26)	89.33 (25)	76.50 (27)
P	17.33	26.67	46.00	56.67	17.03 (42)	63.00 (28)	60.70 (28)	77.63 (25)	23.33	30.67	36.67	38.00	46.77 (42)	32.10 (28)	25.00 (28)	52.00 (25)

[a]Data from one randomly selected day at time point for familiar listeners. [b]Unfamiliar listeners rated speech from both days at each time point. Data reported here are from the same day as for familiar listeners. [c]n=number of words in connected speech sample, which differed from person to person. A dash indicates missing data (child ill). T1, 6 weeks before therapy; T2, 1 week before therapy; T3, 1 week after therapy completion; T4; 6 weeks after therapy completion.

Table III: Single-word and connected-speech intelligibility percentage scores by time by occasion for familiar and unfamiliar listeners

			Familiar listeners				Unfamiliar listeners			
			Single speech[a]		Connected speech[a]		Single speech[a]		Connected speech[a]	
Time	Occasion	n[b]	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	1	7	44.9	16.8	50.7	36.8	33.8	16.4	24.2	24.7
	2	9	45.2	21.4	36.3	26.5	44.9	19.3	25.8	23.3
	Total	16	45.1	19.4	42.4	31.8	39.4	18.7	24.9	23.9
2	1	12	39.5	19.2	49.2	30.8	32.4	17.5	28.6	24.6
	2	4	49.8	30.1	40.0	32.0	35.9	19.8	23.3	22.8
	Total	16	42.1	22.6	46.8	31.0	34.0	18.6	25.9	23.7
3	1	7	59.1	19.9	44.6	29.3	47.7	23.2	47.9	36.1
	2	9	58.0	24.7	61.0	31.1	52.9	21.4	40.2	26.6
	Total	16	58.4	22.5	54.0	31.1	50.3	22.3	43.9	31.6
4	1	9	54.6	16.2	62.3	29.3	50.9	21.7	37.6	31.1
	2	7	60.3	23.6	56.5	33.4	53.9	22.7	43.8	35.4
	Total	16	57.0	19.7	59.8	30.9	52.4	22.1	40.7	33.3

[a]Scores are the percentage of words understood. [b]The number of children rated by familiar listeners: at each time point for each child we randomly selected the recording from either occasion 1 or occasion 2 (all children were rated on both occasions at each time point by unfamiliar listeners).

Familiar listeners

For single words interrater reliability (mean intraclass correlation coefficient) was 0.53, with a 95% confidence interval (CI) of 0.40 to 0.66. Repeated-measures ANOVA indicated significant variation between occasions ($F_{3,45}$=12.1; p<0.001). Most of the difference was between times 1 and 2 (before intervention) and times 3 and 4 (after intervention). A contrast representing this difference was highly significant ($F_{1,47}$=36.4; p<0.001). With this contrast fitted, variation between the remaining occasions (between times 1 and 2 and between times 3 and 4) was not significant ($F_{2,45}$=0.42; p=0.663). The estimated change between the preintervention time points and postintervention time points was an increase in single-word intelligibility of 14.7 (95% CI 9.8–19.5).

For connected speech the interrater reliability (mean intraclass correlation coefficient) was 0.31 (95% CI 0.15–0.47). The variation between occasions was significant ($F_{3,45}$=3.85; p=0.016). Again, most of this variation was explained by a difference between the preintervention recordings and postintervention recordings ($F_{1,47}$=9.67; p=0.003). Once we allow for this difference, the variation between the other time points was not significant ($F_{2,45}$=0.945; p=0.396). The estimated increase in connected speech intelligibility (between before intervention and after intervention) was 12.1% (95% CI 4.3–20.0%).

Unfamiliar listeners

The interrater reliability for single words was 0.83 (95% CI 0.78–0.87). Intelligibility scores were investigated by using multilevel modelling. The first multilevel model included three random effects; in descending order of magnitude there was significant variation between children, significant variation between occasions, and significant variation between ratings. The inclusion of differences between raters as a fixed effect explained a proportion of each of these sources of variation (particularly variation between ratings), but the residual variation in each case remained highly significant. Variation between occasions was then investigated by adding further fixed effects. These models indicated that the largest difference was between samples collected after therapy and samples collected before therapy (times 1 and 2 vs times 3 and 4). The differences between time 1 and time 2 and between time 3 and time 4 were much smaller and not statistically significant. However, there was a difference between the two recordings (made on separate days) at each of the four time points, with intelligibility scores being higher on the second occasion. On the basis of these models the estimated change in intelligibility after the intervention was an increase in single-word score of 15% (95% CI 11.73–18.17%) and the estimated difference between the 2 days within each time point was 4.9% (95% CI 1.7–8.1%).

Interrater reliability for connected speech was 0.67 (95% CI 0.59–0.75). The estimated change in intelligibility after the intervention was an increase in connected-speech score of 15.9% (95% CI 11.8–20.0%). The change in intelligibility between the 2 days at each time point was −0.80% (95% CI −4.81 to 3.21%), which did not differ significantly from zero. There was no evidence of a gradual trend over the four time points.

Agreement between familiar and unfamiliar listeners

For single-word intelligibility the agreement between familiar and unfamiliar listeners was 0.86, with a 95% CI of 0.31 to 0.95. In general, the mean intelligibility scores were higher for familiar listeners than for unfamiliar listeners; across all children across all time points the mean difference was 8.1% (95% CI 4.9–11.3%).

For connected-speech intelligibility the agreement between familiar and unfamiliar listeners was 0.67, with a 95% CI of 0 to 0.87. Again, scores were generally higher for familiar listeners than for unfamiliar listeners; the mean difference between familiar and unfamiliar listeners across all children across all time points was 19.3% (95% CI 13.9–24.6%).

Difference between single-word and connected-speech intelligibility

For familiar listeners the difference between connected-speech and single-word scores was not significant; the difference was −0.3 (95% CI −7.1 to 6.4). For unfamiliar listeners the single-word scores were significantly higher than the connected-speech scores; the difference was 10.8% (95% CI 5.0–16.6%). The difference between single-word and connected-speech scores was greater for unfamiliar listeners than for familiar listeners; the mean difference in differences was 11.1% (95% CI 7.0–15.3%).

Fourteen of the children rated the therapy as 'definitely helpful'; two rated it as partly 'helpful'. All children stated that they would definitely recommend it to a friend.

DISCUSSION

Results of this explanatory study suggest that a short block of intensive therapy focusing on stabilizing children's respiratory and phonatory effort and speech rate can increase the intelligibility of their single words and connected speech to familiar and unfamiliar listeners. No change was observed in the 6 weeks before therapy, suggesting that intervention, rather than maturation or natural change, increased intelligibility. Changes were maintained 6 weeks after intervention, during which time the participants received no speech and language therapy input. This lack of change suggests that the motor routines acquired during therapy were retained.

Intelligibility in single words increased by at least 10% for most children, with some children showing much greater change; change in connected speech was more varied. However, the intelligibility of three children did not seem to change in single words or connected speech (participants H, L and M). Further investigation with larger numbers of participants is needed to gauge whether patterns in response can be predicted for individuals sharing characteristics such as type and severity of speech impairment, receptive and expressive language, and attitude to spoken communication.

With the increases in intelligibility observed, most children in this group should be much better understood in conversation, whether speaking single words or short phrases. Hustad and Beukleman[22] propose that such increases are clinically relevant, and informal feedback from the children, their parents, and education staff supported this view. However, the relevance of the results requires dedicated testing. Furthermore, although children across the impairment range increased their intelligibility, those with severe impairments still require augmentative and alternative methods of communication if they are to be maximally intelligible. For children with severe speech impairments, the therapy tested here may be considered as part of a total communication approach in which children are taught to use a range of communication methods to the best of their ability and to select the quickest, most effective method of communication in every conversation.

The greater intelligibility to familiar conversation partners observed here has also been noted with adults with acquired dysarthria[23] and supports the inclusion of both familiar and unfamiliar listeners in future research to estimate children's intelligibility in their usual conversational environments and their wider community. However, it is important to note the lower interrater reliability scores for familiar raters. This result might also relate to listeners' knowledge of speakers.[23] Some of the familiar raters spent more time with the participants than others: some were teachers and classroom assistants who spent most of their day in the class with the participants; others were therapists who saw the children less frequently. Future research should include some measure or control of familiarity or time spent with participants when investigating the intelligibility of speakers to familiar conversation partners.

The greater intelligibility of single words than connected speech for unfamiliar listeners is important therapeutically. Children may be more intelligible if they use single words or very short phrases when conversing with people they do not know, and they should be encouraged to alter their speech production according to their listener's need. However, greater intelligibility in single words than in connected speech for unfamiliar listeners contrasts with previous research that observed no difference between connected and single-word speech for people with severe dysarthria.[24]

The greater intelligibility of single words may arise from possible floor effects in severe dysarthria, or people with severe dysarthria may speak largely in single words anyway. Alternatively, or additionally, our results may relate to our connected speech task in which speakers described a series of cartoon pictures. This task was adopted in an endeavour to find an intelligibility measure closer to naturalistic speech, and to circumvent the nonrepresentativeness of repetition, reading, and isolated sentence production tasks in reproducing natural speech features, as well as possible literacy issues in connection with reading. However, in this task listeners may perceive a word and then use that word to aid their understanding of the rest of the recording. If they misheard the word they used to help decode the rest of the speech sample they would be more likely to misunderstand the rest of the sample.

Eliciting speech through cartoon description may be more akin to natural conversation than the tasks used in previous research in which listeners heard sentences they knew had no connection to each other. The interpretation using key words, though, may be associated with the increased variability in connected-speech scores in comparison with single words. Furthermore, the number of words spoken was different across children and across data collection points in this study, possibly affecting intelligibility levels, introducing greater variability, and making direct comparison difficult.

Alternative measures of connected speech, which elicit phrases of different lengths within a sample but use similar samples across children and time, are needed for a more reliable examination of the effects of intervention for children with different severities of dysarthria. As noted previously, to measure conversational speech, alternative methods of elicitation should include spontaneous speech rather than modelled speech, but cannot include written passages because of possible differences in literacy skills.

Additional methodology features may account for contrasts in findings with other studies. To maintain children's anonymity we used audio recordings only. We adopted this method because it eliminates confounding visual variables. Visual feedback aids intelligibility in nonimpaired speakers,[25] but conflicting visual–auditory information (possible in children with CP) may depress it. Ideally there would have been a control group of age- and sex-matched participants to establish their level of intelligibility achieved with audio stimuli only as a comparison with the speakers with CP. In this instance we relied on the validated and standardized Children's Speech Intelligibility Measure norms.[12] This is a strict test of intelligibility. Listeners are required to distinguish between (near) minimal pair distinctions in sound production (e.g. pea–tea; four–pour; seat–sheet) without contextual cues to aid their understanding. Free conversation may lead to more intelligible speech than in the measures presented here.[26]

In future research additional measures of change should be considered, to test children's intelligibility in real conversation (question-and-answer routines within structured conversations may be fruitful in this regard) and to measure the generalization of behaviour change (e.g. measures of amount and variety of classroom, home, playground participation). The broader impact of the intervention on children's engagement in different conversational activities at school, in the home and in their communities, and their participation in social life should also be investigated.

Intelligibility was used as the outcome measure of choice here in preference to impairment measures employed in other studies of articulation-impaired speakers (e.g. strength, speed of movements of articulators; acoustic measures in isolation). We argue that it is more ecologically valid, being a gauge of the chief aim of any therapy in articulation disorders, namely to improve intelligibility; it is closer to day-to-day speech performance; and it complements subjective functional ratings that participants or their relatives may make with regard to their impression of possible changes. That does not mean the use of intelligibility measures is without its challenges. Items and materials should be representative of contrasts and complexities of a given language overall and be free from rater biases. We minimized the former by using a standardized validated test; we sought to control for the latter by separating out familiar from unfamiliar listeners, and using matched but not identical item lists at different time points and for different individuals. Among the unfamiliar listeners we sought to even out listener variability from familiarity/learning/order effects, for example, by having each assessment at each time point rated by three independent listeners and ensuring that listeners heard only a small sample of recordings.

Three limitations of this study must be noted. Treatment fidelity was not examined. Although the therapy followed a written protocol, intervention may have differed in which points received emphasis across participants, accounting for some within-group variation. Investigation of treatment integrity should be included in future studies. Second, not all children received exactly the same amount of therapy. The three children who changed little received the fewest sessions of therapy (participants H, L and M). It is possible that a minimum number of sessions are needed to achieve change, and future studies should also include an examination of treatment duration effects. Third, maintenance of effects was examined at 6 weeks only. Longer-term effects should be examined in future studies.

The present investigation explored the potential effects of the programme with older children, whose speech development may have been complete. To capitalize on maturational effects and brain plasticity, a logical claim might be that intervention should be implemented as early as possible. However, there may be a lower (developmental) age limit for the therapy, given that it involves copying new behaviours and repeated practice, and children need to be able to understand instructions and engage in rather abstract practice of speech in single words and phrases. Further exploratory trials are needed to establish a lower age limit for the intervention before its general effectiveness is tested.

CONCLUSION

A short, intensive block of therapy concentrating on maintaining adequate speech volume, effort, and rate was acceptable to the children in our study and was associated with increases in the intelligibility of single words and connected speech to both familiar and unfamiliar listeners. The intervention should be tested further with younger children to investigate whether they, too, may benefit. After this, the general effectiveness of the treatment should be tested in a randomized controlled trial.

ACKNOWLEDGEMENTS

This study was funded by Cerebra, UK. Lindsay Pennington holds a Career Development Fellowship. This report is independent research arising from a Career Development Fellowship supported by the National Institute for Health Research. The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the National Institute for Health Research, or the Department of Health.

REFERENCES

1. Kennes J, Rosenbaum P, Hanna SE, et al. Health-status of school aged children with cerebral palsy: information from a population-based sample. *Dev Med Child Neurol* 2002; **44:** 240–7.
2. Bax M, Tydeman C, Flodmark O. Clinical and MRI correlates of cerebral palsy: the European Cerebral Palsy Study. *JAMA* 2006; **296:** 1602–08.
3. Hodge MM, Wellman L. Management of dysarthria in children. In: Caruso AJ, Strand E, editors. Clinical Management of Motor Speech Disorders in Childhood. New York: Thieme, 1999, 209–80.
4. Love RJ. Childhood Motor Speech Disability. Boston: Allyn & Bacon, 1992.

5. Strand EA. Treatment of motor speech disorders in children. *Semin Speech Lang* 1995; **16:** 126–39.
6. Yorkston KM, Beukelman DR, Strand EA, Bell KR. Management of Motor Speech Disorders in Children and Adults. Austin: Pro-ed, 1999.
7. Workinger MS, Kent RD. Perceptual analysis of the dysarthrias in children with athetoid and spastic cerebral palsy. In: Moore CA, Yorkston KM, Beukelman DR, editors. Dysarthria and Apraxia of Speech: Perspectives on Management. Baltimore: Paul Brookes, 1991, 109–26.
8. Hayden DA, Square PA. Motor speech treatment hierarchy: a systems approach. *Clin Commun Disord* 1994; **4:** 162–74.
9. Pennington L, Miller N, Robson S. Speech Therapy for Children with Dysarthria Acquired below Three Years of Age. *Cochrane Database Syst Rev* 2008; Issue 1. Art. No.:CD006937.
10. Clark M, Carr L, Reilly S, Neville BGR. Worster–Drought syndrome, a mild tetraplegic perisylvian cerebral palsy. *Brain* 2000; **123:** 2160–70.
11. Palisano RJ, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol* 1997; **39:** 214–23.
12. Wilcox K, Morris S. Children's Speech Intelligibility Measure. San Antonio: Harcourt Assessment, 1999.
13. Child Mental Health Service. Department of Child and Adolescent Psychiatry Experience of Service Questionnaire (Child 9–11). 2003. Available at http://www.corc.uk.net/media/File/Measures/ESQ/Self-ReportESQ9-11.pdf. (accessed on April 2, 2009).
14. Maas E, Robin DA, Austermann-Hula S, et al. Principles of motor learning in treatment of motor speech disorders. *Am J Speech Lang Pathol* 2008; **17:** 277–98.
15. Ramig LO, Countryman S, Thompson LL, Horii Y. Comparison of two forms of intensive speech treatment for Parkinson Disease. *J Speech Hear Res* 1995; **38:** 1232–51.
16. Pennington L, Smallman CE, Farrier F. Intensive dysarthria therapy for older children with cerebral palsy: findings from six cases. *Child Lang Teach Ther* 2006; **22:** 255–73.
17. Schmidt RA, Wulf G. Continuous concurrent feedback degrades skill learning: implications for training and simulation. *Hum Factors* 1997; **39:** 509–25.
18. Shea CH, Lai Q, Wright DL, Immink M, Black C. Consistent and variable practice conditions: effects on relative and absolute timing. *J Mot Behav* 2001; **33:** 139–52.
19. Wulf G, Lee TD, Schmidt RA. Reducing knowledge of results about relative versus absolute timing – differential-effects on learning. *J Mot Behav* 1994; **26:** 362–9.
20. Wulf G, Shea JB, Rice M. Type of KR and KR frequency effects on motor learning. *J Hum Mov Sci* 1996; **30:** 1–18.
21. Streiner DL, Norman GR. Health Measurement Scales: A Practical Guide to Their Development and Use, 3rd edn. Oxford: Oxford University Press, 2003.
22. Hustad KC, Beukelman DR. Effects of linguistic cues and stimulus cohesion on intelligibility of severely dysarthric speech. *J Speech Lang Hear Res* 2001; **44:** 497–510.
23. DePaul R, Kent RD. A longitudinal case study of ALS: effects of listener familiarity and proficiency on intelligibility judgments. *Am J Speech Lang Pathol* 2000; **9:** 230–40.
24. Hustad KC. Effects of speech stimuli and dysarthria severity on intelligibility scores and listener confidence ratings for speakers with cerebral palsy. *Folia Phoniatr Logop* 2007; **59:** 306–17.
25. Keintz CK, Bunton K, Hoit JD. Influence of visual information on the intelligibility of dysarthric speech. *Am J Speech Lang Pathol* 2007; **16:** 222–34.
26. Hustad KC. The relationship between listener comprehension and intelligibility scores for speakers with dysarthria. *J Speech Lang Hear Res* 2008; **51:** 562–73.